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/ 1924.

AGRICULTURAL ESSAYS.

No. 1.

SOILS.

BY

THOMAS BALDWIN,

Lecturer on Agriculture, Albert-Model Farm, Glasnevin.

DUBLIN:

WILLIAM ROBERTSON, 23, UPPER SACKVILLE-STREET.

SIMPKIN, MARSHALL, AND CO., LONDON.

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1859.

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TO

THOMAS KIRKPATRICK, ESQ., M.D.,

HEAD INSPECTOR OF (IRISH) NATIONAL AGRICULTURAL SCHOOLS, AND SUPERINTENDENT OF THE ALBERT AGRICULTURAL INSTITUTE, GLASNEVIN.

MY DEAR DOCTOR,

I take advantage of a time-honored custom to dedicate this short Essay to you; and wish thereby to record my sense of the deep obligations which the rising generation of Irish Farmers owe you for your able and unremitting advocacy of Agricultural Education, and for the zeal and devotedness with which you have addressed yourself to the arduous duties entrusted to your care by the Board of Education in organizing and conducting the truly national Agricultural school system which you superintend, and more especially the national institution over which you preside. Nor can I forbear saying that, personally, I feel largely indebted to you for the disinterested friendship which I have always experienced at your hands.

I remain, my dear Doctor,

Yours very faithfully,

THE AUTHOR.

4, PROSPECT, GLASNEVIN,
May 2nd, 1859.

CONTENTS.

SOILS.

CHAPTER I.

GENERAL CONSIDERATIONS ON THE CONSTITUTION OF SOILS.

1. THE soil forms one of the most important of agricultural subjects. As it is the medium in which the seed germinates and vegetates, and in which the plant grows and becomes matured, its cultivation is the great business of the arable farmer. In order to transact this business with the utmost economy and profit, we require to know the nature and properties of soils, the modes of improving and cultivating them, how they are affected by crops, the various circumstances which influence their value, and the several means of maintaining their fertility.

2. The word soil means the earth in which plants grow, and in which the *ordinary* implements of husbandry work. It varies in depth from a few inches, "as when it covers the clay-slate of Down and Monaghan," to several feet; and varies in material and character from the sands to the clays and the peats. Those who have been schooled in elementary chemistry can, to a certain extent, penetrate into the secrets of this interesting labyrinth, which, but a few centuries ago, was considered one of the four elementary or simple bodies, fire, air, earth, and water. Underneath the soil lies what, by way of distinction, is called the subsoil. It differs from the soil generally in color and physical properties, though they contain the same mineral ingredients. Another characteristic difference between them is, that there is less of the remains of plants and animals, or, in other words, less organic matter in the subsoil. Immediately lying beneath the subsoil is a "solid floor" of hard rock, which sometimes becomes the subsoil. In some cases the soil and subsoil were produced by the gradual wearing away of the underlying rock; but, in the great majority of cases, the layers of soil have been deposited by the seas and rivers of former ages, just as similar deposits are at this moment in course of formation at the bottom of our oceans, seas, and lakes.

3. If you take a portion of soil and thoroughly remove the water by drying, then place it over a strong fire on a piece of clean iron, you will find it darken in color, and soon the blackened matter will disappear altogether, leaving a quantity of matter behind which resists the action of the fire. The part that burns away is composed of oxygen, hydrogen, nitrogen, and carbon, and forms what is technically called the *organic* portion of the soil, and the incombustible portion, or what does not burn, is called the *inorganic* matter. The relative proportions in which these two kinds of matter exist in soils are very various; some, as the poorest sands and the cinnamon soils of Ceylon, contain as little as one-half per cent. of organic matter; others, as the peaty soils, contain as much as seventy per cent. of this kind of matter. "Oats and rye," says Johnston, "will grow on a soil containing only one or one and a-half per cent.; barley, where two or three per cent. are present; but good wheat soils contain in general from four to eight per cent., and, if very stiff and clayey, from ten to twelve per cent. of organic matter."

We may assume five or six per cent. as the average quantity of organic matter in fertile soils. In good garden mould it often amounts to 20 or 24 per cent. of the weight of the soil, and is seldom less than ten or twelve per cent.

4. It was, until very recently, believed that the fertility of the soil depended on the presence of organic matter; but, though a certain proportion of it is essential, we find that soils containing only two or three per cent. of this kind of matter are more fertile than others containing eight or ten per cent. of it. Voelcker found about three or three and a-half per cent. of organic matter in the best wheat soils which he analyzed; and Dr. Anderson gives the following table of the amount which he found in the best wheat soils in different parts of Scotland:—

	Per-centage of organic matter in the soil.	Per-centage of organic matter in subsoil.
Mid-Lothian wheat soil	10·19	4·83
East-Lothian do.	6·32	5·85
Morayshire do.	4·54	3·76

Dr. Hodges' analysis of the soil of the Munster Model Farm gives 3·93 present of organic matter, and 2·05 in the subsoil. It is a very good soil, yielding superior samples of wheat, beans, oats, and barley: wheat, in good seasons, averages eight to twelve barrels per acre He found that the soil of the Albert Model Farm, Glasnevin, contained 14·21, and the subsoil 3·04 per cent. of organic matter. The latter soil contains rather too much organic matter for the growth of cereals. Turnips, mangold wurtzel, and cabbages delight in a loamy clay soil, such as the one under consideration; but in order to suit it for the growth of cereals, the quantity of organic matter

should evidently be decreased. Several practical remedies suggest themselves:—1st. The application of quick lime, which decomposes this kind of matter; 2nd. To grow root crops by the aid of mineral manures only; 3rd. Charring, a practice which has been recently carried out with success, and to which we will again refer.

5. Whence have soils derived their organic matter? The answer to this question is interesting. When first formed, rocks contained no vegetable matter; when vegetables were called into existence, they must have found a suitable place in which to grow. But, granting that a soil was at first destitute of organic matter, its formation in it would be produced thus:—A tribe of plants, of a low scale of organization, would grow upon it, deriving their organic matter solely from the air. These plants dying, and their roots decaying, would leave vegetable matter in the soil. The same process takes place at the present day in our soils. The roots of the heather accumulate on the mountain soil; the roots of trees, grasses, and weeds in woods; the roots of our cultivated plants in arable land; and the roots of grass rapidly increase the quantity of vegetable matter in our pasture fields. When, accordingly, we want to enrich sandy or light soils, we lay them down to grass; and hence, among other reasons, the adaptation of the five-course and six-course rotations to such soils. Besides the decay of the roots of plants, there are other sources of the organic matter of soils. The decay of insects is one of these sources. Snails, worms, &c., which perform certain functions while living, give to the soil by their death and decay organic matter of a most valuable character, being richer in nitrogen than the roots of plants. The disintegration of the more recently-formed geological formations also adds animal matter to the soil. The limestone, for instance, contains more or less of such matter.

6. Speaking of the organic nature of soils, Johnston observes (Lectures, p. 93): "1. That plants will, in certain circumstances, grow in a soil containing no sensible quantity of it; but it is also true, generally, that they do not luxuriate or readily ripen their seed in such a soil. 2. It is consistent with almost universal observation, that the same soil is more productive when organic matter is present than when it is wholly absent. 3. That as a field of arable land contains less organic matter after a crop growing on it than before it was sown, plants take a certain portion of their organic food from the soil."

7. The organic matter exists in soils in various forms; sometimes in brown or black fibrous portions, exhibiting, on a careful examination, something of the original structure of the organized substances from which it has been derived; sometimes it forms only a fine brown powder, intimately intermixed with the mineral matters of the soil; and sometimes it is scarcely perceptible in either of these

forms, and exists only in the state of organic compounds, more less or void of color, and at times entirely soluble in water (Johnston).

8. The term humus has been given to the fine, brown, light, organic matter of soils, and it has been considered to consist of various organic compounds formed in the soil during the decay of the organic matter. The composition of these organic compounds (as many as sixteen of which have been described) in the soil, have been elaborately detailed by Dumas, so detailed, indeed, that they possess no interest to the practical man, while many eminent chemists doubt the existence of many of them. The principal of these are the humic acid group; the ulmic acid group, the result of a less advanced stage of decomposition than the humic; and the geic acid group, the result of a further decay of the humic and ulmic acids under the influence of oxygen. These three groups are separated from the soil by boiling a portion of it with common carbonate of soda, and adding to the brown solution thus obtained muriatic acid, until the liquid has a sour taste, when brown flocks fall. These flocks consist of one or a mixture of those acids. They combine with lime, magnesia, oxide of iron, and alumina, forming salts. They dissolve readily in solutions of ammonia; and hence, manures containing or capable of producing this substance must facilitate their admission into plants. They are also soluble in carbonates of potash and soda; and therefore the ashes of weeds and burned soils which contain these salts must exercise on the acids named a similar effect to ammonia.

9. Besides these three groups of compounds which are insoluble in water but soluble in solutions of salts of the alkalies, the organic matter of the soil contains—1, a part soluble in water alone, and 2, a part insoluble in either. The former consists chiefly of two acids, *crenic* and *apocrenic*, which are readily washed out of the soil by rain, and which form insoluble compounds with peroxide of iron, and are therefore found in many of the ochry deposits from ferruginous springs.

10. Humus has been distinguished into *mild*, *sour*, and *coaly* (Johnston). The *mild* gives a brown color to water, but does not render it sour; gives a dark-brown solution when boiled with carbonate of soda; evolves ammonia when heated with caustic potash, or soda, or slaked lime, and when burned leaves an ash which contains lime and magnesia. The *sour* gives, with water, a brown solution more or less acid; is less favorable to vegetation than the mild; and generally indicates a want of lime in the soil. The *coaly* humus gives little color to water or to a hot solution of carbonate of soda; leaves an ash which contains little lime, occurs generally on the surfaces of very sandy soils, and is very unfruitful. It is greatly ameliorated by lime or wood ashes.

11. Humus is lighter, more porous, and looser than the mineral constituents of the soil. It absorbs more water than clay or any other constituent of the soil, and thence acquires a soft, swollen-up consistency, without, however, loosing its permeability or becoming sticky or tough; it gives up the absorbed water very slowly through evaporation. It may be compared to a sponge, which in like manner has the power of absorbing large quantities of liquids, that become uniformly diffused through it, and are slowly yielded up again. In consequence of these properties humus renders heavy soils lighter, dense soils more porous, tough soils softer and mellower, and impenetrable soils more open; and on the other hand, it renders light and loose soils more dense, and loosely coherent and dry soils moister (Stockhart).

12. The inorganic part of the soil contains the following substances: lime, silica, alumina, magnesia, potash, soda, oxide of iron, oxide of manganese, chlorine, sulphuric, carbonic, and phosphoric acids. The great bulk of the inorganic part of soils consists of silica, alumina, and lime. Unlike any of the other substances named, alumina does not enter into the composition of plants, and its use seems to be to give stability to the soil for the support of plants, and to absorb and retain several ingredients which would otherwise be washed out of the soil.

13. It is only the fine particles of the soil which immediately afford nourishment to plants. If the matter that remains, after burning away the organic part of the soil, be introduced into a bottle, a Florence flask for example, and some water poured upon it, agitating it for some minutes, so as to break up any hard lumps of earth, and be then allowed to remain at rest for a couple of minutes, you will observe that a finely divided matter remains floating in the water, which scientifically considered is, as Dr. Madden long since remarked, a mixture of an impalpable powder with a greater or smaller quantity of particles or fragments of rocks of various sizes and shapes; the impalpable powder is the part which directly exerts an influence upon vegetation: the other matter gives porosity, and thus admits air which, as we will see, produces food for plants. It is the finer part which keeps soils moist and gives them the power of absorbing fertilizing matters from water and other fluids. By gently pouring this water with its suspended matter from the vessel, and repeating the washing with fresh water so long as it comes off muddy, you will at last obtain in the vessel a mixture of sand and gravel, which, when dried can be separated by means of a small sieve, and their proportions determined. If you allow the water used for washing the soil to remain at rest till all sediment falls to the bottom, and pour it off gently and evaporate it, a few grains of solid residue remain behind. This is the soluble portion of the soil.

"An examination of the gravelly matter thus separated shows that

it consists of fragments of rocks of various kinds, resembling those in the neighbourhood or other parts of the country. An examination of the finely divided matter desposited from the water used in washing would show that the bulk of it consists of silica in combination with alumina, and of varying proportions of lime, magnesia, oxide of iron, oxide of manganese, phosphoric acid, &c. In the insoluble portion of the soil most of these substances exist in combination with silica, and the silicates which they form are capable of being decomposed and slowly dissolved by the influence of the gases contained in rain water, and they thus afford plants their mineral food. In the residue after evaporation (the soluble portion of the soil) the chemist discovers the same substances, but in such states of combination as to dissolve readily in water."—(Hodges.)

14. Now, a chemical analysis of a soil gives the quantities of the several ingredients in the finely divided matter of the soil, the gravelly particles being altogether overlooked. "A statement of the quantities of fertilizing matters contained in a specimen of a soil, such as is furnished by its chemical analysis, merely serves as an inventory of the riches stored up for use in its treasury, but does not enable us to calculate how far the mass of capital is directly available for the immediate requirements of the cultivator." The state of combination and availability of the several ingredients is scarcely determined by the analyst; nor does he ascertain in every case the mechanical condition of the soil itself. A chemical analysis, however, serves the following purposes: 1st. It tells the quantity of matter stored in the soil (without always specifying how far available). 2nd. It shows if any substance essential to plants is absent; and in this respect, it is a test of the value of a soil. It would be utterly hopeless, for example, to expect crops to grow in a soil totally destitute of lime, or any other fixed ingredient of plants. 3rd. When crops fail upon a farm it is one of the means of ascertaining the cause of infertility. The analysis of the soil of the Model Farm shows that it contains too much organic matter and too little lime. Many soils, again, contain too much oxide of iron or too much acid matter, which is readily detected by chemical analysis.

15. It has lately become the fashion to look upon chemical analysis as the best means of estimating the value of soils. The agricultural public have somewhat over-estimated the advantage of the application of chemistry to land valuation, and especially those who have embarked in agriculture for the first time. They have overlooked and under-estimated every other consideration, such as the experience of the ordinary land-valuators of the country, and have sought information in the balance, crucibles, and other appendages of the laboratory. Many chemists have been candid enough to warn the farmer against this false idea. One of the most pains-

taking of modern analysts observes:—"The dissimilarity in soils in regard to natural capacity of producing crops cannot be accounted for by reference to a certain amount of chemical compounds; on the contrary, it is certain that the combinations which the several substances may form in the soil, and which combinations are not generally indicated in the analysis, may give rise to the superiority of one soil over another." We have passed as it were from one extreme to another. Formerly only the physical properties of a soil were considered important in estimating its value; but for the past twenty years or so little or no attention has been paid to those important mechanical and other physical characters on which the value of soils so much depend.

16. The soil of Bagshot Heath, a barren waste, has been compared with the Tchornoi Zem, or the black earth of the central regions of Asia, which, on the testimony of Sir Roderic Murchison, yielded abundant crops of wheat, &c., without any manure. If, says Mr. Rham, the 70 per cent. of silica which the Tchornoi Zem contains were in the form of small crystals, such as we find in the sea-sand, and the 13 per cent. of alumina combined with the 7 per cent. of iron and the sulphuric acid, were mechanically mixed with the sand, the result would be a soil not much superior to that of Bagshot Heath; and although the 6 or 7 per cent. of organic matter, especially with a considerable portion of animal matter, may give it some fertility, it would never be fit for the growth of wheat for the want of firmness. But if the alumina is combined with the silica, so as to form clay, and a portion of the silica only is in the form of fine sand, making with the clay a loamy soil, and the oxide of iron be a peroxide, not hurtful to vegetation, then the organic matter intimately mixed with this soil will form the richest wheat-loam.

17. The range of variation incidental to the determination of some of the constituents of the soil exceeds the total quantity of those ingredients present in it. They sometimes exist in it in quantities too limited to be determined, but yet in sufficient abundance to meet the requirements of several successive crops. "In the determination of the quantities of phosphoric acid and of potash, two of the most important constituents contained in the soil, the limits of variation attending those determinations may amount to from 0·1 to 0·2 of a per cent., which is often as much as many soils capable of growing crops contain" (Voelcker).

18. In reviewing Mr. Smyth's system of culture at Lois Weedon, Professor Way throws some light on this point. In the first column in the following table are given the numbers of pounds weight of the different mineral substances required by a crop of wheat yielding 35 bushels of grain and 2 tons of straw and chaff; and in the second column are given the quantities removed by 20 such crops:—

	One crop.	20 crops.	Per-centage of the soil removed by 20 crops.
	lbs.	lbs.	lbs.
Silica	170	3,400	·152
Phosphoric Acid	30	600	·027
Sulphuric Acid	8	160	·007
Lime	16	320	·014
Magnesia	10	200	·009
Potash	40	800	·036
Soda	3	60	·003
	277	5,540	·248

The quantities of phosphoric acid and potash removed by 20 crops of wheat are far under the range of variation given above, which goes far to prove the utter impossibility of, at present, relying on chemical analysis as a means of knowing if a soil contained phosphoric acid and potash enough to grow a crop of wheat.

19. Again, there seems every reason to believe that iodine, bromine, and fluorine are essential constituents of soils; and up to the present time no analysis includes these substances. Iodine exists in wood and in fresh-water plants; bromine has been detected in several soils and plants; and fluorine exists in the bones and teeth of animals, and must have existed in the soils which produced the plants on which those animals fed.

20. A well-known chemist, Mr. Nesbit, principal of the Kennington College, gives a homely illustration of the value of an analysis of a soil. He says it reminds him of a man who, having a house to sell, brought a brick in his pocket as a specimen. Not that in any ordinary-sized farm there are likely to occur as many variations of soils as there are bricks in an ordinary-sized house built of bricks; but yet, the variations on a farm, nay, often in an average-sized field, are so great as to render the parallel quite legitimate. These variations, it is true, do not always exist, and even when they do, precaution is taken to have several samples from different parts of the fields mixed together for analysis. This expedient is, however, but a small remedy for the evil pointed out.

21. Dr. Daubeny, in 1845, made a most intelligent division of the ingredients of the soil. He divided them into *active*, *dormant*, *and passive*. When we consider, with this distinguished philosopher, the nature of a soil in an agricultural point of view, or in reference to its suitableness for the growth of various kinds of vegetables, two questions suggest themselves: 1st. What amount of ingredients is in it at present in a condition to be available to nourish vegetables? and 2nd. What amount of ingredients is in it capable of becoming available

for this purpose in the course of time. In nature, rain-water (water charged with carbonic acid) is the agent which dissolves the food of plants; and accordingly, all that can be extracted from the soil by this means is called the active food of plants, and what cannot be so extracted ought not to be regarded as at present available for the nourishment of crops. The matter again extracted from the soil by digestion in muriatic acid during four or five successive hours, is dormant, but capable of becoming available in the course of time. Whatever remains after digestion in the acid is in such a state of combination that it may be considered wholly incapable of imparting any nourishment to plants for a very long period of time. The muriatic acid, if applied first, dissolves both active and dormant ingredients. Both of these make up the total *available* constituents in the soil; whilst those which, from their state of combination in the mass, can never be expected to contribute to the growth of plants, may be denominated the *passive* constituents. A useful analysis should set forth the several quantities of the ingredients of the soil existing in an active and dormant condition. It appears that part of that which Dr. Daubeny called passive may become available sooner than he supposed. Take silicate of lime, for example, of which more at another time, (see also Johnston on lime, p. 63-5). Though the farmer is generally ignorant of the fact, many of his operations are directed to the conversion of the dormant into active ingredients. We expose, for instance, our land to the winter's weathering, the good effects of which, are like those resulting from many other operations of tillage, referable to this very plain theory.

22. Viewed in this light, it is easy to comprehend how a soil may refuse to grow crops and yet contain within itself a large quantity of dormant ingredients. Such a soil is benefited by a year's fallowing, by green fallow cropping, by tillage of any kind, or by manure. Which of these methods to adopt at any time is determined by circumstances. "It may be important to the farmer to be assured that at the very time the most distant quarters of the globe are ransacked for the mineral ingredients required for his crop, he has lying in the soil an almost inexhaustible supply of the same ingredients! The soil, considered as a store-house, may be full. All the substances needed by the plant may be present in it, and in sufficient quantity; the fault may be one, not of the existence but of the accessibility of those substances."

23. What, then, are the proportions, chemically speaking, in which the several ingredients exist in the soil? Though a definite reply cannot be given to this query, yet there is a coincidence in this respect among fertile soils; and though chemical analysis is not an infallible guide, yet it often shows a striking deficiency of certain mineral substances in infertile soils. Johnston gives the following concise and

suggestive table, which may be occasionally used for reference:—

COMPOSITION OF SOILS OF DIFFERENT DEGREES OF FERTILITY.

	Fertile without manure. Produced crops for sixty years without manure, and still continued to do so.	Fertile with regular manuring.	Barren.
Organic matter	97	50	40
Silica (in the sand and clay)	648	833	778
Alumina in the clay	57	51	91
Lime	59	18	4
Magnesia	8½	8	1
Oxides of iron	61	30	81
" manganese	1	3	½
Potash	2	trace.	trace.
Soda } chiefly as common salt.	4	—	—
Chlorine } chiefly as common salt.	2	—	—
Sulphuric acid	2	¾	—
Phosphoric acid	4½	1¾	—
Carbonic acid (combined with the lime and magnesia)	40	4½	—
Loss	14	—	4½
	1,000	1,000	1,000

24. We will not stop here to consider the various properties of the several mineral substances which, according to the foregoing table, enter into the composition of plants, as that part of the subject has been admirably treated of in such popular manuals as "*Hodges' Lessons in Chemistry in its Application to Agriculture,*" and "*Johnston's Elements of Agricultural Chemistry.*" But it comes within the scope of those general remarks to answer the question—whence has the inorganic matter of our fields been derived?

25. The mineral as well as the vegetable and animal kingdoms undergoes important changes under the influence of the mighty hand of nature. The most indurated rock crumbles to dust in the course of time. Without borrowing remote illustrations, let us reflect on the weather-worn aspect of public buildings in some city or town in temperate climates. Look, for instance, at the ancient city of Chester, which became the great rendezvous for the agriculturists of the United Kingdom last July, with its fine old cathedral and other edifices, whose walls have been wrinkled by time, and corroded by the united influence of air, moisture, and heat.

26. The corrosion or wearing down of rocks is produced partly by chemical and partly by mechanical agencies. Two of the principal chemical agencies may be briefly explained thus:—

27. 1st. It may be remarked that of all the constituents of rocks iron is most susceptible to the influence of the atmosphere.

Iron combines with oxygen in two proportions: the first combination is termed protoxide and the second peroxide of iron. The protoxide, which exists in many varieties of rocks, has a powerful affinity for oxygen, which it takes from the air, and being thereby increased in bulk, in consequence of its conversion into peroxide, it bursts the rock. Silica and potash occur in most varieties of rocks, forming silicate of potash; but by the action of the carbonic acid gas, which exists in the atmosphere, the silicate is decomposed, the potash combines with the carbonic acid forming the very soluble substances termed carbonate of potash, which is washed out from the rock. Felspar is an abundant constituent of granite, gneiss, &c., and is very readily decomposed on exposure to the air, by reason of its large amount of silicate of potash.

28. 2ndly. Rain water, which always contains more or less carbonic acid, exercises powerful action in disintegrating rocks. For example, limestone (which is chiefly composed of carbonate of lime) is insoluble in pure water, but soluble in water charged with carbonic acid. Of course the action of rain-water is very different on different rocks. Some, such as the pure sandstones, quartz, and lava cinders, are scarcely at all acted on by it, while it acts readily on feldspar and other minerals containing silicates of alumina and alkalies, such as basalts and clay slate.

29. Among the mechanical agencies which aid in producing soils may be mentioned:—1. Gravitation, which brings matter from higher to lower levels; such as, when the particles of an over-hanging rock are held together by a slight affinity, they gravitate into the hollows. 2. Winds, which frequently transfer to a distance the particles of the disintegrated rock. On the Baltic shores large tracts of arable land are annually covered with drift sand, and on the south-west coast of France the Dunes increase every year about seventy feet in breadth.* 3. Water, which, besides aiding in promoting chemically the degradation of rocks, acts mechanically in several ways.

30. The abraded particles of rocks are transported to a distance by mountain rivulets, streams, and rivers. Immense quantities of alluvial matter are deposited daily at the mouth of the great Mississippi in this way. The deltas of the Nile, &c., and the valuable tracts of reclaimed slob lands of Wexford and Lough Foyle have been produced in the same way.†

31. The mechanical effects of water are well exemplified along coast lands, where the splashing waves, by their momentum, constantly encroach upon the dry land, and frequently steal away, bit by bit, a favorite piece of arable land from the farmer, who seldom receives any compensation further than that derived from the reflec-

* Morton's Cyclopædia of Agriculture, vol. ii. p. 868.

† The Rhine has been computed to bring down, in the course of 2,000 years, material which would cover thirty-six square miles to a depth of three feet. The gigantic delta of the Ganges, which covers 20,000 square miles, has been deposited by that river.

tion that the matter so abstracted from him may, after lying for centuries at the bottom of the sea, be upheaved by volcanic agency, and made subservient to the requirements of future generations.

32. But the most interesting mechanical way in which water acts in producing soil from rocks is by its freezing. Rocks absorb water, which, on freezing, (or being reduced to the temperature of 32° F. and under), increases in bulk, and ruptures the rock with a force and to an extent proportionate to the amount of water absorbed.* In thawing the water is reduced to its original bulk and liquid state, and the particles of the rocks crumble down. As we shall afterwards see, the action of frost in mellowing and pulverizing the land is precisely similar.

33. Vegetation also contributes, in no small degree, to the degradation of rocks. No sooner is the rock sufficiently abraded than inferior plants strike their roots into the merest fissures, and, subsequently increasing in bulk, rupture the rock. The dynamic force exerted in this manner by trees is sufficient to bear down walls and houses. In common with many others I have often observed the remarkable effects produced by insignificant plants in destroying some of the stratified rocks. The plants which Dr. Hodges most frequently observed is the wild sorrel, *Rumex acetossela*, the roots of which he has found "forcing themselves for a great length between the layers of the clay-slate rock, and in their progress loosening and finally tearing them asunder."

* According to Mr. Wilkinson

	lbs.		st.
A cubic foot of the chalk of Antrim weighs	160	and absorbs of water,	8
" shaly calp,	160	"	1 to 4
" sandstone,	145 (average.)	"	1 to $5\frac{1}{3}$
" granite,	170 (average.)	"	Newry and Kingston, $\frac{1}{4}$; Glenties in Donegal, 4
" basalt,	178 (average.)	"	less than $\frac{1}{4}$
" clay roofing-slate,	177 (average.)	"	$\frac{1}{4}$

(See Hodges' Chemistry.)

CHAPTER II.

THE SEVERAL CLASSES OF SOILS.

34. The nomenclature and classification of soils are in a most unfortunate state of ambiguity. The expressions, light soils and heavy soils, so frequently met with in treatises on agriculture, are intelligible enough to the initiated, while to the reader not acquainted with the phraseology of the field, the terms light and heavy, as applied to soils, merely convey the idea of specific weight, which is totally different from the secondary or technical meaning of the words. And as to the classifications of soils in common use, we shall presently see that they are vague and unsatisfactory.

35. Various experiments instituted from time to time, though pretty fully detailed in agricultural journals, are faulty for want of a uniform class of terms expressive of the various conditions of soils. For instance, in the current number (63, January, 1859), of the transactions of that admirable institution, the Highland Society of Scotland, we have two *prize* reports on experiments to test the relative merits of ploughs; and apart from the utter absurdity of the object aimed at in those experiments, the interest which would otherwise attach to them is, to the scientific reader, diminished by the paucity of information conveyed by the essayists as to the physical properties of the soils experimented on. One says his soil is a "friable clay mixed with quartz;" but whether there was much or little of the latter is not specified; and he informs us that the subsoil was *sandy clay*. The other essayist, also the recipient of the Highland Society's gold medal, reports that his soil is a "clayey loam, resting upon a retentive red sandy clay subsoil," which is all the information he vouchsafes as to the character of the soil on which he tested no less than ten ploughs, differently constructed, notwithstanding that different classes of soils require certain modifications in that implement.

36. In the book of instructions issued to Griffith's valuators (in this country) in 1853, a number of terms occur which, with a few others, I may place before the reader:—

A soil is said to be *stiff*, *heavy*, or *strong*, when it is tenacious and difficult to labor: clay soils are stiff. Soils which are loose and easily labored are said to be light or friable: sandy and gravelly soils are light. Now, as a given bulk of sand is heavier than the same bulk of clay, it is evident that the term heavy and light, as applied to soils, are calculated to lead to some confusion.

When a soil has considerable depth of mould it is said to be *deep*. Griffith applies the term to soils exceeding ten inches in

depth. When the plough, in turning an ordinary furrow slice, descends into the subsoil, the soil is said to be *shallow*.

A *sharp* soil is one which keeps the plough-irons and other implements of husbandry clean. It contains sandy, gravelly, or gritty matter. "Such a soil is admirably adapted to turnips." Loamy gravels are sharp.

A *deaf* soil is opposite to sharp, and contains so much vegetable matter as to keep the plough-irons always dirty: deep, black moulds and peats are deaf.

A soil becomes *sick* when the same crop is too often repeated. Thus, if clover or turnips be repeated too often on a field, it becomes sick of that crop, and refuses to grow those crops healthily.

A *worn* soil is one that has borne consecutive crops without manure.

Porous or *open* soils and subsoils freely allow the passage of water.

Retentive soils and subsoils, on the contrary, retain water and obstruct its downward passage through them: stiff and adhesive soils are retentive.

Soft or *firm* soils contain no gravel, and are composed chiefly of fine particles of sand or soft light earth.

Hard soils, such as the thin retentive clays, are the very opposite to soft soils.

Soils which contain more water than is required for vegetation are said to be *wet:* clays, in their natural state, and peaty soils are wet.

Dry soils, on the contrary, are thin; and water passes through them freely: sandy and gravelly soils are dry.

Rich soils yield good crops without large quantities of manure.

Poor soils, owing to the bad quality of the land, require liberal manuring to produce good crops: thin soils are generally poor. The term hungry is somewhat synonymous with poor: gravelly soils which require inordinate quantities of manure are hungry.

A soil is said to be *grateful* when it gives a greater return than might be expected from it under given treatment: sandy loams are grateful, especially the lighter loams.

A soil is *kindly* when it admits of the usual operations of husbandry being performed in due season with perfect safety.

37. Various classifications of soils have been proposed from time to time, all, however, based on somewhat similar principles. Schuhler, who has done much to elucidate the nature of soils, in his work on *Agricultural Chemistry*, gives a most elaborate division, which, though too abstruse to be of practical utility, formed the groundwork of most modern classifications.

38. Von Thaer, in his well-known work on agriculture, gives a list of soils, in which he attempts to estimate their relative value according to the proportion of clay, sand, carbonate of lime, and organic matter which they contain. The following table embodies his arrangement:—

Thaer's Classification of Soils.

No.	Classes.	Per centage of clay.	Per centage of sand.	Per centage of carbonate of lime.	Per centage of humus.	Relative value.	Observations.
1	First class of strong wheat soils	74	10	4½	11½	100	From the large proportion of organic matter in 1, 2, and 3, they are not so stiff as the quantity of clay would indicate.
2		81	6	4	8½	98	
3		79	10	4	6½	96	
4	Rich barley land,	40	22	36	4	90	A fine clay loam, not difficult to work.
5		20	67	3	10	78	Adapted to barley by the large quantity of sand and humus combined with the clay.
6	Good wheat land,	58	36	2	4	77	This will require rich manuring to keep it fertile.
7		56	30	12	2	75	
8		60	38		2	70	
9	Ordinary do.	48	50	A small quantity in each of those soils.	2	65	
10		68	30		2	60	
11		38	60		2	60	
12	Good barley land,	33	65		2	50	
13	Ordinary do.	28	70		2	40	
14	Oat and rye land,	23½	75		1½	30	14 and 15 are so light that folding is often the only means of getting them to grow remunerative crops.
15		18½	80		1½	20	

39. Mr. (now Sir Richard) Griffith, in the work of instructions to valuators already referred to, gives the following classes and sub-classes:—

Classes.	Sub-classes.	Remarks.
Argillaceous or clayey.	Clayey. Clay loam. Argillaceous alluvial.	The color of soils, as yellow, blue, brown, or red, is derived from an admixture of different proportions of the oxide of iron.
Silicious or sandy.	Sandy. Gravelly. Slaty or rocky.	
Calcareous.	Limey. Limestone gravel. Marl.	
Peat soil.	Moor. Peat.	

40. Professor Hodges has recently proposed the following more precise system of classifying soils:—

Hodges' Classification of Soils.

	Name of soils.	Proportion of sand left on being washed.
These contain less than 5 per cent. of carbonate of lime.	1. Pure clay,	Leaves no residue of sand when washed. Porcelain clay is an example.
	2. Tenacious clay,	Leaves 5 to 20 per cent. of silicious sand. Brick clay is an example.
	3. Clay loam,	Leaves from 20 to 40 per cent. of residue when washed.
	4. Loamy soil,	Leaves from 40 to 70 per cent. of sand.
	5. Sandy loam,	Leaves from 70 to 90 per cent. of sand.
	6. Light sandy soil,	Leaves more than 90 per cent. of sand.
These contain more than 5 per cent. of carbonate of lime.	7. Marly soil,	Yields from 5 to 20 per cent. of carbonate of lime.
	8. Calcareous soil.	Yields more than 20 per cent. of carbonate of lime.
Contain more than 5 per cent. of organic matter.	9. Garden soil.	Contains from 5 to 20 per cent. of organic matter.
	10. Peaty soil.	Contains more than 20 per cent. of organic matter.

41. It must be confessed that these classifications convey little immediate practical instruction to the farmer, nor can it be denied that they are far from being perfect; for a practical man cannot distinguish between soils differing only in one or two per cent. of organic matter, carbonate of lime, or any other ingredient; and yet Dr. Hodges would place a soil containing say 19·5 per cent. of silicious sand in the class of tenacious clay, and a soil containing say 20·5 per cent. of the same substance in the class clay loam.

42. The more mineralogical classification of the great French author, M. de Gasparin, and which has been highly lauded, is still more faulty.

43. It were very desirable that we had an intelligible and unfailing classification of soils; but science must become very much simplified before this can be accomplished. Minerals are distinguished with ease; but owing to their complex nature and endless variations we need never expect to recognise soils by their characters and properties as definitely as we distinguish stones, &c., by the study of mineralogy.

I quite agree, however, with Gasparin, that should such a mode of classifying soils be devised, "it will facilitate very much the study of agricultural treatises, and the different methods of culture will be rendered the more intelligible by description; and a necessary link being established between agriculture and geological and other natural sciences, the former will materially profit by the advancement of the latter branches of human knowledge."

44. Clay, sand, lime, and organic matter being the substances which form the great bulk of, and give their primary characters to, soils, we may enlarge a little on the properties of clay, sandy, calcareous soils, and peaty soils.

45. We will here explain the words, sand, siliceous sand, and gravel. Sand means the finely divided matter of the soil; and it may be composed of particles of silex or lime or any other mineral. When the sand is composed of silica, it is called siliceous sand. Gravel consists of larger particles than those which compose sand. In the words of Low:—"Any light soil, mixed with a sufficient portion of stones, is gravel, and, therefore, gravel is merely the different kinds of light soils mixed with a greater or less proportion of stones." Gravelly soils vary in fertility perhaps more than any other class of soils. The inferior gravels are worth very little, and consist of siliceous sand mixed with stones, and are the hungriest of all soils. When the sand or earth is of a calcareous or clayey character, and the stones undergoing decay rapidly, we have the richer gravelly soils, which, notwithstanding their open texture, yield, where there is sufficient organic matter, excellent crops of barley and oats.

CHAPTER III.

CLAY SOILS.

46. The terms alumina and clay are generally understood as synonymous; but the word clay, in the language of agriculturists, does not mean pure alumina. Clays owe their tenacity to alumina; and the purest clays, or those containing most alumina, are the porcelain clays; but when freed from water, by heating to redness, these contain only from 42 to 48 per cent. of alumina, with from 58 to 59 per cent. of silica (Johnston). Antisell gives the following composition of the porcelain clay or kaolin met with in Wicklow, Down, and Tipperary:—

Silica	47·0
Alumina	39·2
Water	13·8
	100·0

The term *pure clay* has been adopted by authors as a kind of standard of comparison. It is the pipe-clay of these countries, and contains from 36 to 40 per cent. of alumina, 3 or 4 per cent. of oxide of iron, and a trace of lime, and is not so strong as the pure porcelain clay; it consists of the latter, with a mixture of siliceous and ochry particles in so intimate a state of mechanical union that they cannot be separated by washing. The strongest clay soil in

cultivation rarely contains more than 35 per cent. of alumina. The strongest clay soil (unctuous, tile-clay), says Johnston, consists of what is above called pure clay, so mixed with from 5 to 20 per cent. of siliceous sand that the latter can be separated by boiling and decantation.

47. A pure clay is thus described by Stephens:—"When fully wetted it feels greasy under the foot, which slips upon it in all directions. It has an unctuous feel in the hand, by which it can be kneaded into a homogenous mass, which retains the shape imparted to it. It glistens in the sunshine, retains water upon its surface, and makes water very muddy, but the mud is slow in settling at the bottom. It feels cold to the touch, and soils the hand and everything that comes in contact with it. It cuts like soft cheese; parts with water very slowly. When dry, a clay soil cracks into numerous fissures, collects into lumps, which are very difficult to be broken, and which indeed cannot be pulverized by the ordinary implements. It absorbs moisture readily and adheres to the tongue. When in a medium state, neither wet nor dry, it is tough, and soon becomes hard with a little drought, or soft with a little rain. On these accounts it is the most obdurate of all soils to manage. A large number of horses is thus required to work a clay-land farm; and its workable condition continues only for a short time, even in the best weather. But it is a powerful soil in its capabilities, bearing luxuriant crops, of excellent quality. It may be characterised a naturally fertile soil, containing little vegetable matter, and of a yellowish-grey color. It generally occurs in deep masses, on a considerable extent of flat surface, exhibiting few undulations, along the margin of a large river, or its estuary, and being evidently a deposition from water."

48. Strong clays are often found baked on the surface, while they are moist underneath. The continued evaporation from their surface keeps them always cold. The faults of clay soils lie in their texture, and not in any deficiency of mineral ingredients, of which they contain an abundance. They are improved by drainage, which carries off that superabundance of water which renders them often useless. Lime, too, acts beneficially on them, by increasing their porosity and rendering their mineral ingredients available for plants. The addition of sand tends to render them more friable and useful. The quantities to be applied depends of course upon the texture, &c., of the soil. The application of recent or fresh farm-yard manure also opens up clay soils to the action of the air, for in fermentation it separates the particles of the clay to a certain extent.

49. Clay soils are sometimes called argillaceous soils, from the word argil, which is applied to alumina, as being a white substance. The term alumina has been derived from alum, of which it forms the base. Alumina has a great affinity for water, which it retains with tenacity, and communicates this property to clay soils, in proportion to

the quantity of the alumina which they contain; it enters into combination with numerous other substances in the soil, giving rise to a great variety of compounds which perform most important functions in vegetal nutrition; it has a great affinity for lime, and for silicic acid (silex) with which it forms silicate of alumina. As appears elsewhere, the power which soils possess of absorbing and retaining ammonia and other fertilizing ingredients in the soil has been traced by Mr. Way to the double silicates of alumina and lime, &c., and we find that these valuable double compounds exist in greatest abundance in clay soils, which, if properly cultivated, possess this absorbent power to the greatest extent. The property of absorbing moisture freely, and retaining it with tenacity, and which is accompanied with the power of absorbing gases largely, and which, in the natural state, injuriously affects clays, may, in the hands of the skilful cultivator, be made the key to their productiveness.

50. Clay soils are of various shades of color, but they are generally black or reddish. The colors of all soils are chiefly owing to the prevalence of oxide of iron and the decaying remains of animals and vegetables.

51. What is the quantity of alumina usually present in fertile soils? Our answer to this question can only be viewed as a general approximation. Dr. Voelcker* gives the following analyses of clay soils in the neighbourhood of Cirencester:—

	No. 1.	No. 2.	No. 3.
Water driven off at 212° F.,	5·58	...	...
Organic matter and water of combination,	8·62	8·88	6·11
Oxides of iron,	8·07	8·82	8·84
Alumina,		6·67	
Carbonate of lime,	·74	...	...
Lime,	...	1·44	·41
Magnesia,	·60	·92	1·49
Potash,	·26	1·48	·65
Soda,	·22	1·08	...
Phosphoric acid,	·88	·51	·04
Soluble silica,	1·45	72·83	80·69
Insoluble silicates (fine clay),	84·10		
Chlorine and sulphuric acid,	traces.	traces.	traces.
Carbonic acid and loss,	...	2·87	2·27
	100·	100·	100·

A soil from Nebstein, in Moravia, containing 8·51 per cent. of alumina, was celebrated for yielding successive crops of corn without manure for 160 years. Another from the banks of the Ohio, North America, a virgin soil celebrated for its fertility, contained 5·66 per

* Morton's Cyclopedia of Agriculture. See also the analyses, foot note, p. 24.

cent. of alumina, and a third, from the Polder of Alt-Arenberg, in Belgium, and which bore scourging crops of beans, wheat, oats, barley, &c., for nine years, contained 4·81 per cent of alumina. Good fertile soils contain about 5 per cent. or so of it. Though the absorbent powers of soils is, to a certain extent, in proportion to the compounds of alumina already mentioned contained in them, yet the per-centage of alumina which a soil contains does not, alone, afford a criterion of its value; but it is one of those invaluable aids which should guide the practical man in estimating the commercial value of a farm.

52. Clay arises principally from the disintegration of rocks containing feldspar, a mineral which is the chief source of alumina. All clay soils contain alkaline matter, potash or soda, and their fertility is, in no small degree, owing to the presence of this kind of matter. The physical properties of excluding air and retaining water, conceal the fertilizing powers of clay soils, and it is the business of the intelligent cultivator to correct the former and develop the latter. The alkalies are mostly present in an insoluble state in clays, and the admission of the air with its watery vapour and carbonic acid would render these available for plants.

Burning has also a good effect on clays.

53. While agriculture was imperfectly understood and as imperfectly practised—while we had neither artificial manure nor green crops for our light lands, clay soils were considered the only valuable ones. They contained such an abundant store of fertilizing ingredients that the only expedient necessary to be resorted to when they got tired, was the naked fallow, and in the more early and primitive period of agriculture, simple rest. It was at one time universally believed, and the notion is still entertained by many uneducated farmers, that the earth required rest, and rest only, to repair its lost fertility. Gradually, however, experience changed this opinion in favor of naked fallowing, and since the introduction of root crops, the naked fallow has, in turn, given way to green crop fallowing; and now we can clearly comprehend that the benefit of *rest*, as generally understood, was delusive.

It is only on stubborn, stiff clays that intelligent farmers now-a-days adopt the naked fallow. It is practised on the adhesive carses of Scotland and some of the clays of England and Ireland; but it is gradually disappearing, as intelligence and increased facilities and improved practices extend.

54. The management of a stiff clay soil is perhaps the most critical among the whole range of agricultural pursuits. During the last season ('58), we saw some clay-land farmers completely thwarted in their plans. The secret of success lies in taking timely advantage of every favorable moment for tillage that presents itself; not to make the already adhesive soil more plastic by working it while too wet, nor yet entail the increased outlay its culture

involves when too dry; in short, to take time by the fore-lock, and operate on a clay soil when it is in a happy medium. Many clay soils, in addition to their stiffness, contain oxides and salts of iron in such quantities as to render it difficult to produce crops. In this case they require manuring and judicious culture, such as liming, burning, and frequent stirring. This is more particularly true of thin or poor clays, which are the most worthless of soils when out of condition.

55. In a moist climate it is almost impossible to overdrain strong clays, and especially when there is not only a surface soil of clay, but also a retentive clay subsoil, a combination which taxes the most intelligent and experienced agriculturist. The drains must be deep and at frequent intervals; and, in addition, it may be necessary to have the land in narrow ridges in winter with good surface water-furrows, the want of which, and ploughing at inopportune seasons, are the most common mistakes committed in the management of clay lands. "We often find clay-land farmers, who resort to the naked fallow, plough the land while it is wet in summer;" and the consequence is that the sun bakes it, so as to render the ingress of the air into it impossible, and thus render the operation injurious. "The drainage may be aided by forming surface or water furrows, so that the furrow slice may be so free from moisture as to readily disintegrate under the influence of the weather. This should be done immediately before winter, and then the frost will so divide and mellow the soil, that, provided it be kept free from superfluous water, by under-drainage and water-furrows, it will have the appearance of a fine mould when worked in spring. It should have received the necessary manuring in autumn, and be ready for the seed to be sown on the pulverised surface," for the great object should be to have the land in such a state that the seed may be put in with the utmost despatch.

56. The strongest clay soils are mostly laid down to permanent pasture, for which they are well adapted; and, perhaps, no better system could be adopted in many situations. Drought has little or no effect on such pastures. This class of soils are late in maturing crops, and especially so in unfavorable seasons.

57. In many cases, again, clays are subjected to the most scourging system of wheat and bean cropping. As a general rule fibrous-rooted plants are best adapted to strong soils, as it is only in such situations that they find adequate support to bear their heavy burthen. Fibrous-rooted plants, having what are called tap-roots, such as wheat, beans, red-clover and the oak, particularly delight in stiff clay soils. Bulbous plants, on the other hand, do better in lighter soils; but, in truth, by judicious management we may grow any of our ordinary crops with success on light or heavy lands, unless those of extreme qualities in either class. Maximum crops of wheat or beans, however, are not obtained from light land, nor maximum returns of barley or turnips from the stiffest clays.

58. At another time we will treat of the courses of cropping adapted to clays, &c.; at present, therefore, we will only remark upon this point that the foregoing considerations should always be taken into account in framing a rotation of crops for heavy soils. It may also be well to distinguish between the deep rich clays and the poorer clays. The former are such unrivalled wheat producers that they are usually styled wheat soils. The poorer clays are generally very unprofitable. They are mostly shallow and rest on retentive subsoils. The consequence is, that they are cold, and require expensive manuring and tillage to yield an average return. The herbage which they yield in their natural state is inferior; and in addition to efficient drainage it is quite evident they must be deeply tilled and liberally manured.

CHAPTER IV.

LIGHT SOILS.

59. Light soils have been divided into: sandy, gravelly, calcareous, and peaty. A pure sandy soil possesses little value. When wet, it feels firm under foot and ploughs with a pretty firm furrow slice. It cannot be compressed into a ball with the hand. When rubbed between the fingers it is rough and grating; when dry it feels soft, and is so yielding to pressure that an object of any weight sinks in it. Most sands are easily drifted by the wind. Sand, without losing its distinctive characters as a soil, may possess cohesiveness in its particles naturally; and then the soil denominated sandy becomes of deserved estimation. The poor sands are easily known by their scanty herbage, a character which they possess in common with the inferior gravels. Rich sands are very early in maturing their crops.

60. Sandy soils cover a great area, and generally occur in deep masses near the termination of the estuaries of large rivers, along the sea, and in the interior of counties. They are of all degrees of fertility, from the barren wastes of Central Africa to the kindly loamy sands of our own country. Siliceous sands have for their basis the well known substance, silex or flint, which acts the part of an acid in combining with bases, and is therefore called silicic acid. It is a most abundant earth; forming a large portion of soils and rocks.

61. The proportion of silica which exists in soils is very various. Like alumina, there is no fixed rule as to the quantity which denotes fertility, so far as it depends on this substance. Voelcke quotes the following—

ANALYSES OF SANDY SOILS, BY SPRENGEL.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Silica and quartz sand, .	96·0	92·01	90·22	98·8	96·7	94·7
Alumina, . .	·50	2·65	2·10	·6	·4	1·6
Oxides of iron, . .	2·0	3·19	3·95	·3	·5	2·0
„ manganese, .	trace	·48	·96	...	...	...
Lime, . . .	·001	·14	·54	·1	trace	1·0
Magnesia, . .	trace	·70	·73	·1	·1	trace
Potash, . .	do.	·12	·06	...	trace	} ·1
Soda, . . .	do.	·02	·01	...	do.	
Phosphoric acid, .	do.	·07	·36	...	do.	trace
Sulphuric acid, . .	do.	trace	trace	...	do.	...
Chlorine, . .	...	do.	·01	...	·1	...
Organic matter (humus)	1·50	·49	1·04	...	2·2	·5
	100·	100·	100·	99·9	100·	100·

No. 1 is a barren sandy soil in Luneburg.
No. 2. Sandy soil on the Weser, producing very bad red clover.
No. 3. In Brunswick, yielding luxuriant crops of pulse.
No. 4. Very barren drift sand, near Meppen.
No. 5. Barren sandy soil, near Aurich, east Friesland.
No. 6. Fertile sandy loam, near Brunswick, producing luxuriant crops of lucerne, sanfoin, lupins, poppies, &c.

Since writing the foregoing, Dr. Voelcker has given the composition of two sandy soils near Cirencester, Gloucestershire, which he has recently analyzed:—

	No. 1.	No. 2.
Organic matter and a little water of combination, .	5·36	4·82
Oxide of iron and alumnia, ...	5 78	12·16
Carbonate of lime, ...	·25	·15
Potash, soda, and magnesia, ...	·49	·46
Phosphoric acid, ...	none	faint trace
Sulphuric acid, ...	trace	trace
Chlorine, ...	trace	trace
Insoluble silicious matter (chiefly quartz sand, with but little clay),	88·12	82·41

Both these soils are rather deficient in phosphoric acid, potash, soda, and, in short, the more valuable constituents of soils. Even lime is contained in them in too limited quantity, and so is sulphuric acid; or, as the professor observes, "both are poor soils that require to be heavily manured before they can be made to yield a remunerative crop."

Those analyses are given in a paper of great practical interest on liquid manure, in which Dr. Voelcker concludes that this species of manuring produces the most marked effect on light soils, while on clays it produces a contrary effect. The following extract embraces the most salient points in the professor's paper:—

Speaking of the clay soil he remarks, "that the surface soil abounds in all the mineral matters which are required by cultivated

plants, and also contains an appreciable quantity of nitroginized organic matters. If we calculate the total amount of the available fertilizing substances for a depth of soil of only ten inches, we shall find a quantity of mineral and organic fertilizing matters, in comparison with which the amount of manuring constituents supplied in 50,000 gallons of liquid manure (even more concentrated than that used by Mr. Mechi in Essex) appears altogether insignificant. I believe this to be the chief reason why little benefit results from the application of liquid manure to clay soils and fertile friable loams."*

Referring to the effects of liquid manure on light or sandy soils, he says:—" Hungry soils, similar in composition to those of which the analyses are given (in p. 23), are grateful for almost any kind of manure, for, as they are greatly deficient in plant-food, manures that contain even small quantities of phosphoric acid or alkalies (such as liquid manure) must produce a beneficial effect. Several of the liquid manures which I have examined, compared with other fertilizers, are poor manures. And for the reasons first mentioned, liquid manure of this description cannot produce any marked effect upon naturally fertile land (such as clay soils), but on poor sandy soils it unquestionably may be used with very great benefit."—*J.R.A.S. England*, vol. xix.*

62. Sandy soils are light in texture; that is, they are loose and porous, naturally dry, and easily labored. But light lands (omitting the inferior sands) are now the most useful soils of these countries. They are, *par excellence*, the land for turnips, which is one of the staple crops in modern agriculture.

* The following is the composition of the soil referred to in this extract:—

COMPOSITION OF A MODERATELY RETENTIVE SOIL AND SUB-SOIL.

	Surface soil.	Sub-soil.
* Organic matter and water of combination,	4·88	2·59
Alumina,	2·15	5·39
Oxides of iron,	3·15	7·16
Lime,	·77	·26
Magnesia,	·13	1·22
Potash,	·49	·88
Soda,	·13	·28
Phosphoric acid,	·12	·19
Chlorine,	trace	trace
Carbonic acid,	·31	1·79
Insoluble silicates and sand,	88·41	86·24
Consisting of Silicic acid,	85·11	66·11
Alumina,	2·36	14·55
Lime,	...	·85
Magnesia,	·50	·23
Potash,	·25	1·77
Soda,	·09	·21
	100·00	100·00
* Containing nitrogen,	·182	·09
Equal to ammonia,	·220	·11

63. The general management of strong and sandy soils is totally different. While the clays are habitually wet, sandy soils are naturally dry. If a sandy soil rests on a porous subsoil, no amount of rain can injure it. Indeed, from its porosity and want of attraction for water, there is great difficulty in raising good crops on such a soil. When under a green fallow crop, for instance, the moisture dissipates so readily that every precaution must be taken to retain a sufficiency of it. The raised drill, by exposing a large surface to the air, is, in many cases, unsuited to the lighter class of soils, especially in dry districts. And accordingly we find green crops grown on the unraised or flat drill system in such situations.

"In moist climates," says Vallentine, "raised drills leave a kind of water-course or channel between the artificial heights, which act most conveniently for carrying the superfluous moisture away, and not only that, but the ridges are left, in the intervals of dry weather, in a proper state for working the land, for the horse and hand-hoeing, as the case may be. Where, as in Ireland and Scotland, forty inches of rain fall in a year, with a much less average temperature than in the south and east of England, raised drills are decidedly preferable, as the flat surface would usually be a puddle; but the case is completely reversed in the dry districts of England just named, where little more than twenty inches of rain fall annually. The summer heat is also greater, and, of course, the *evaporation* is far more than in Scotland or Ireland."

64. One of the chief causes of the many failures that occur in turnip-growing on light land, is the undue exposure of the soil immediately before the time of sowing. In the case of clays, every time we expose a fresh surface we may expect some beneficial result, unless the ground is wet; but every time a fresh surface is turned up on light land in May or June, the turnip-sowing season, we must expect an injurious effect by an escape of moisture. A clay soil retains sufficient moisture in the driest season; but a light soil has no such retentive force.

65. The practice of autumn cleaning, which is now coming into use, is well adapted to light-land farming We would recommend the cleaning and ploughing of light land in autumn, and agree with Mr. Vallentine, that "all soils which have a tendency to lose moisture quickly should be prepared, as far as possible, for the turnip crop in autumn." If light land is cleaned in autumn it has time to acquire consistency and moisture, before spring, and only requires a grubbing and harrowing before drilling at seed time, by which the "natural sap" is retained in the soil. If any circumstance should prevent autumn cleaning, the next best thing is to prepare it as early as possible in spring, before the heat advances so as to dissipate the moisture. "Some years ago the practice was general, and, in some districts, is still continued, of ploughing turnip-fallows, even clean land, three or four times in spring and sum-

mer, for the purpose of pulverizing the soil and making it work well; such a practice on light soils is quite against the economy of labor and the chance of securing a turnip-braird, as it dissipates the moisture of the soil." We think it right to quote here the opinion of an able writer—Mr. Clare Sewell Read—who, in his report of Norfolk farming, says: "When these light lands of Norfolk are *clean*, autumn cultivation does more harm than good. They are sufficiently friable by nature, and do not want to be finely pulverized or constantly stirred, as the heavy winter rains then wash more of the manure into the porous subsoil; so that the best farmers (where the land is *clean*) give a good winter ploughing before Christmas, and thus grow better turnips than when the soil has been well cultivated after harvest."—*J. R. A. S. England*, vol. xix., p. 283.

66. The time and mode of applying manure should be materially influenced by the character of the soil. There can be no doubt, but that by ploughing-in the farm-yard manure, in its recent or fresh state, we add most fertility to the soil. To add to this there is, in the case of clays, the additional advantage, that in decaying the manure tends to open up or render the soil more loose and open. It would seem, however, that this explanation is opposed to applying recent manure to light soils; nevertheless, if applied in autumn, no injury can result; on the contrary, it is found to increase the retentive power of the soil for moisture. There is one important consideration, however, in connexion with this subject; namely, is the soil capable of retaining the elements of fertility as they are liberated in the decaying manure? Clay soils have this power, and the practice may with safety be carried out on those soils; but owing to the facility with which water descends through sandy or light soils, and the little power they possess of taking up the elements which it dissolves out of the manure, we apprehend the practice of autumn-manuring is not a safe one on the lighter soils.

67. When, and in what state, then, should farm-yard manure be applied to light turnip lands? In answering this question, we may review its bearings:—1st, by allowing manure to ferment, it diminishes in value; 2nd, if applied in a recent state in autumn and ploughed in, it is liable to be washed out of the soil; 3rd, if applied in a recent state at or before seed-sowing, it renders the soil still lighter and more liable to part with its moisture; and, besides, it will not have become available for the crops in due time. Under these circumstances, it is evident that the best system is to form the manure into heaps, in which, while it decomposes, loss of any of the liberated elements is prevented; and to apply it under the seed in a pretty well decomposed state.

68. In treating of manures, we will show that farm-yard manure can be prevented from undergoing any depreciation in value, by carefully covering it with earth, peat mould, &c., in the heap. Manure should be covered in as fast as it is applied to light land,

and the seed sown immediately after; for on light soils, the difference of a few hours, and certainly of a day or two, may materially affect a green-crop. The manure, too, suffers injury by exposure; but far more injury is done during a hot day by loss of moisture than by loss of the elements of the manure itself. "The system practised by many, of dunging a great breadth of turnip-land at once, is highly injudicious on the average of seasons, when it is desirable to *retain moisture* in the soil; and those who follow such a course fail more generally than they succeed in getting a regular braird. The land may lose by injudicious exposure, with a rough surface, more moisture in a few days than it can obtain from an ordinary fall of rain." Let the careless farmers reflect on this, and guard against the evil which it involves—an evil of serious moment.

69. On the after-culture of green crops, on light lands, there is some difference of opinion. One agriculturist tells us, that we cannot too frequently employ the hoe and other implements, as the more finely pulverized the soil, the more moisture it absorbs. That this is true, there cannot be a doubt. The gardener always recognises the fact, and is incessantly hoeing and digging, &c. The farmer, too, is aware of it. But if it gives a greater surface for the absorption of moisture, it gives the same increased surface for the evaporation of moisture. We think clay lands cannot be too frequently stirred, as they absorb freely and part with moisture tardily. The case is different, however, with light soils, which should be only hoed just as frequently as is necessary to keep down weeds, and retain the surface open for the admission of air. The frequent horse-hoeings of high drills must prove injurious on light soils, especially when the implement "cuts down the sides of the drills so much as to leave but a narrow strip of earth containing the plants, exposed to the sun's heat on all sides." Hand and horse implements must, therefore, be used with caution and discretion on light soils.

70. The crops best adapted to light soils are bulbous-rooted plants, such as turnips, carrots, &c.; also oats, barley, and rye. These follow each other in a regular course of cropping, suited to this class of soils. Light soils will not bear such frequent cropping with grain as clays; nor will they all grow remunerative crops of wheat and beans, unless improved in texture by the addition of clay or marl, or some other means. They do not yield the more valuable farm plants, but produce abundant returns of the more useful crops. Laying these soils down to grass is a frequent means of renovating them. As the roots of the grasses accumulate and decay in the soil, they add to it organic matter, in which sandy soils are naturally deficient; this, besides directly increasing fertility, also gives them a degree of consistency which enhances their value. It is for this reason that the five course (two years' grass) is better adapted to light soils than the four course (one year's grass). If

very light, a six, seven, or eight years' course may be followed, by which the land is in grass three, four, or five years.

71. By sheep-folding on turnips, many light-land districts have been greatly improved: in some cases, the rental has been increased fourfold. We have examples of this improvement on the most extensive scale in Norfolk and other parts of England. The sheep consolidate the ground, and enrich it by their excrements. It has been truly remarked, that "turnips are the sheet-anchor of light-land cultivation." Thousands of acres of light lands, now yielding remunerating crops, would have remained in a worthless state, had it not been for the introduction of turnip husbandry, with all its various accompaniments of artificial manures, &c., which have in no small degree contributed to enhance the value of this class of soils.

72. Among the other means of improving sandy soils, may be mentioned: first, green manuring, which adds organic matter to them. This consists in growing rape, turnips, buckwheat, or any other crop with an abundance of green foliage, and ploughing them in where they grow before forming their seeds; second, applying farm-yard manure, which is also abundant in organic matter; third, peat, which also abounds in organic matter, and which should be made into a compost; fourth, claying; fifth, marling, which is similar in practice and principle to claying. As the first three and the last of these processes belong to the subject of manures, we shall notice, in this place only, the fourth, namely, claying. According to our definition of manures, claying may be considered under that head; nevertheless, it is so peculiar to sandy soils, that we may introduce it here. Clay has been applied to land in three ways: first, in its natural state, as dug from under, or found on the surface of the ground; second, in a calcined or burnt state; third, in a compost with lime and other substances. It is of the first we are now to speak.

73. The quantity of clay per acre necessary to be applied, in order to correct the bad qualities of a sandy soil depends: first, on the quality of the clay; second, on the character of the soil to be improved. If the clay be calcareous, it will resemble marl in its effects. If it contains much alumina, it will impart the more firmness and retentiveness to the soil; and when the clay contains ochry or ferruginous matter (as many clays do), it will only injure and poison the soil. Clays, of a white sandy nature, are bad, but those of a pliable, and more or less unctuous character, and of a solid consistency, are always safe.

74. It takes 134 cubic yards to cover an acre an inch deep. This may not appear at first a heavy application; but when it is considered that the ordinary depth of cultivation does not exceed eight or ten inches, it will at once be seen that this is a very heavy dose. The usual application may be said to vary from 58 to 120 cart loads, the average being about 80.

Autumn or early winter is the usual time for applying clay to sandy or light soils, as the weather is then likely to pulverise the clay and incorporate it with the soil.

75. *Calcareous Soils*, which have lime for their basis, effervesce with acids, and are very extensive in this country, covering for the most part the limestone formation which extends over the great central plain of the island. Generally speaking, calcareous soils incline more to the denomination light than heavy soils. They are never met with of such incoherency as light sandy soils; but form sharp, kindly, and productive soils, not too difficult to labor. When there is much clay in calcareous soils they are wet and spongy, and difficult to manage; but when properly treated, yield good crops of wheat and beans included, &c. When much sand is present, they partake of the character of sandy soils, and yield excellent crops of turnips and barley. In this case, too, the rotation and mode of culture should be similar to those adopted on light soils; in the former, the treatment should approach that of clay soils. Calcareous soil very generally rest on an open sub-soil.

76. The five-crop course answers very well on the limestone soils of this country. These soils form excellent pasture for sheep. As a general rule, they are well adapted to the growth of useful crops and mixed husbandry.

77. In England this class of soils (called chalk soils) are very abundant. They rest on the chalk formation, which covers a large area in the south of that country. When derived from the lower chalk formation, the soils partake of the character of clay; when from the upper series, which is flinty, the soils are light, and are chiefly kept in permanent sheep-walks. They yield a short sweet herbage. The constant treading in of the dung of the sheep, and the stimulating effect of their urine, gradually increase the quantity of vegetable and animal matter; and thus the turf becomes close and rich. But if this thin coat be disturbed by the plough and mixed with the chalk, it will, after one or two tolerable crops of corn, be reduced to its original sterility; and it requires ages to restore the fine pasture which once covered it. Such is the case with the Southdown Hills, in Sussex and Wiltshire, on which are kept the celebrated Southdown race of sheep. But the chalk has in many places been carried down by the rain, and transported in a comminuted state to the sandy or clayey valleys around them, and by this mixture has greatly improved both, forming various loams and marls in themselves highly fertile, or very useful in increasing the fertility and texture of other soils.—(*Rham*).

78. In treating of the foregoing classes of soils, we have not adhered to the table of classification, p. 16. Had we done so, it were necessary to treat of "marly" as distinguished from "calcareous soils," according as they contained from five to twenty or more than twenty per cent.

of carbonate of lime; but the mere quantity of lime in a soil is not alone a practical criterion as to its value, nor is it always an exponent of its properties. The practical distinction between a marly and calcareous soil, is that the latter is generally more open and porous. Marl varies very much in character. When it is a clay marl, the soil partakes of the character of a clay soil; when sandy, the marly soil possesses the character of a sandy soil. I quote Voëlcker's

ANALYSIS OF A MARLY SOIL FROM NEAR CIRENCESTER.

Organic matter and water of combination,	10·50
Oxide of iron and alumina,	11·92
Carbonate of lime,	19·92
Carbonate of magnesia,	·25
Potash,	·62
Soda,	·09
Phosphoric acid,	·38
Sulphuric do.,	·04
Soluble silica,	13·45
Insoluble silicates and sand,	42·07
Loss,	0·75
	100·00

CHAPTER V.

LOAMY AND PEATY SOILS.

79. There is no term more frequently used in speaking of soils than the word *loam*, the meaning of which is somewhat indefinite. Sir Humphrey Davy defines it as "the impalpable part of the soil, which is usually called clay or loam;" and Hugo Reid says, "the term loam is applied to soils which consist of about one-third of finely-divided earthy matter, containing much carbonate of lime." At present the term loamy is applied to soils containing a sensible quantity of finely-divided and decomposed organic matter. Thus, if a sandy soil contains five or six per cent. of such matter, it may be called a sandy loam, in which state it is most productive. We use the terms clay loam and calcareous loam, when clayey and marly soils contain a pretty large proportion of organic matter. Voëlcker's definition is very intelligible. He says, "the term loam is reserved to all soils which contain the five chief constituents—siliceous sand, clay, lime, and vegetable and animal remains, in a high state of division, intimate mixture, and in such relative proportions that the quantity of lime does not exceed five per cent., nor that of clay fifty per cent." In well cultivated districts the great breadth of the land is loamy.

80. All soils improve as they approach the state of loams. Clay-loams are most valuable soils, and form the best and most widely-extended wheat soils of these countries. "A clay-loam," says

Stephens, "forms a lump by the squeeze of the hand, but soon crumbles down again. It is easily wetted on the surface with rain, and then feels soft and greasy; but the water is soon absorbed, and the surface again becomes dry. It is easily wrought, at any time after a day or two of dry weather. It becomes finely pulverized; is generally of some depth, forming an excellent soil for wheat, beans, Swedish turnips, and red clover, and of course oats, potatoes —in short, every crop; and is of a deep brown color, often approaching to red." We may class as clay-loams the fertile alluvial deposits on the margin of rivers, and which are next in richness and fertility to the richer garden moulds.

Sandy and gravelly loam are also very useful soils, being neither too wet nor too dry, and if maintained in a state to really deserve the denomination, they grow all crops in average abundance. It is true that abundant manuring and judicious management are required to render them capable of producing good crops of wheat and beans; but they yield turnips, barley, and grass in perfection.

ANALYSES OF LOAMY SOILS.

	Anderson.				Playfair.
	No 1.		No, 2.		No. 3.
	Soil.	Subsoil.	Soil.	Subsoil.	
Silica,	63·19	61 63	74·39	73·64	81·26
Peroxide of iron,	4·87	6·23	4·71	4·92	3·41
Alumina,	14·04	14·24	5·54	9·38	3·58
Lime,	0·83	1·27	1·39	0·71	1·28
Magnesia,	1·02	1·39	·74	·84	1·12
Potash,	2·80	2·17	1·71	·15	·80
Soda,	1·43	1·04	·67	·03	1 50
Sulphuric acid,	·09	·03	·10	·20	·09
Phosphoric acid,	·24	·26	·14	·16	·38
Carbonic acid,	·05	·02	·006	·006	trace
Organic matter,	8·55	6·82	6·82	5·85	2·43
Water,	2·70	4·57	4·42	4·25	2·60
Loss,	...	...	...	...	·68
	99·83	99·86	100·24	100·21	100

81. The classes *garden* and *peaty soils* of Hodges correspond with the general class *moulds* of other writers. The term mould is a very vague one. "Any soil," says Voëlcker, "containing more than six per cent. of organic matter, whatever else its composition may be, is called a vegetable mould. Soils of the most opposite physical characters are thus grouped together." An idea of the indefinite manner in which this term has been used may be learned from the fact that in the same page of the Cyclopædia of Agriculture, in which this

definition is given, occurs the foregoing table "of analyses of loamy soils," No 1 of which contains 8·55 per cent of organic matter!

82. Having already expressed an opinion as to the proper quantity of organic matter which should exist in fertile soils, it only requires here to treat of peaty soils, under which denomination all soils containing a superabundance of this kind of matter are classed.

83. The term bog should be restricted to a soil wanting firmness. It, too, is a rather indefinite term. (1) Thus if water is put up near the surface of the ground, the latter is rendered soft or boggy, or what we call a quagmire. Efficient drainage at once effects an improvement in such a case, if the soil contains the elements of fertility. This kind of bog occurs only in small isolated patches. (2). There are large tracts of bog in these countries which, in addition to inconsistency and wetness, contain a vegetable formation more or less deep. This kind of bog is very abundant in Ireland, and is cut for turf, and subsequently reclaimed. This formation is called *peat*, "a substance of vegetable origin, found wherever the soil has been soaked with water which has no outlet, and does not completely evaporate by the heat of the sun." According to Thaer peat differs from the ordinary humus, or vegetable mould of grass fields, woods, &c , only as having had a different origin. He defines it a kind of humus; but it requires an intermixture with such substances as lime, potash, &c., to neutralize its acid principles.

84. A *moor* means an extensive waste, covered with heath, and the soil consisting of poor light earth, mixed generally with a considerable portion of peat. *Moss* or *moss-land* is frequently confounded with moor-land. The former has a vegetable origin, and has been produced by an accumulation of aquatic plants. "When it has a considerable depth, and its substance has lost all power of vegetation, it forms peat-bog." Moss, peat, and bog, may therefore be treated together, while *moor* forms a soil distinct in its infertility and cultivation.

85. There is some difference of opinion as to the origin of our bogs. The most accurate and scientific report on the subject is the paper which Mr. Moore, the able curator of the Royal Botanic Gardens, Glasnevin, read at the last meeting of the British Association in Dublin (1857). He divides Irish bogs into three classes:—(1) red bog; (2) brown bog; and (3) black bog. The first, which is the most valuable for fuel, and varies in depth from ten to forty feet, is the most extensive species of bog in this country, being, according to the report of a Government commission on Irish bogs, upwards of a million of English acres, more than two-thirds of which is westward of the Shannon. The *brown* bog differs from the red in being differently colored by mineral matters, and being in a more decomposed and compound state. The black bog, which is sometimes seen in isolated patches through the red bog, and appears, from the solidity and darkness of color of the matter of which it is com-

posed, to have been formed on the sites of small lakes, which have been slowly and gradually filled up by the decomposition of such floating plants as are now forming matter to fill up the water holes on flow bogs. By far the greater portion of black or turbary bogs appears to have accumulated on the sites of ancient forests, which either lined large portions of the country, or skirted along the margins of morasses, as is evident from the number of roots and trunks of trees found in it. Mr. Moore says that the plants which now grow on the surface appear to have been those which formed the principal part of the peat. This variety of peat is the most valuable for fuel, owing to the large quantity of woody matter it contains, and varies in depth from three to twenty feet or more.

A variety of compact black bog is found at a higher elevation than any of those mentioned, covering large tracts on the slopes of mountains. On the drier slopes, where the fall is so great as to prevent water from lodging, the best kinds of peat earth for horticultural purposes are obtained, especially on sandstone formations, when the *débris* of the rock enters largely into the composition of the mass.

Another variety of bog is found at a still higher elevation, and may, in consequence, be truly called mountain bog. It varies in depth from two to twelve feet, as mentioned in Portlock's report on the Geology of Londonderry, to the depth of the bog in Knocklayd at an elevation of 1,685 feet. The elevated mountains of Wicklow and Dublin are in many parts covered with this kind of bog.*

86. Mr. David Page, in his advanced Text Book of Geology, says that "peat, which is a product of cold or temperate regions, arises chiefly from the annual growth and decay of marsh plants, reeds, rushes, equisetums, grasses, sphagnums, confervæ, and the like, being the main contributors to the mass, which, in process of time, becomes crowned and augmented by the presence of heath and other shrubby vegetation. Peat-moss has a tendency to accumulate in all swamps and hollows; and wherever stagnant water prevails, there it increases, filling up lakes, choking up river-courses, entombing fallen forests, and spreading over every surface having moisture sufficient to cherish its growth. It occupies considerable areas in Scotland and England, though rapidly disappearing before drainage and the plough; but it still covers a wide extent of surface in Ireland. It is found largely in the Netherlands, in Russia, and Finland, in North America, and in insular positions, as Shetland, Orkney, and the Falkland Islands. Besides the peculiar plants which constitute the mass, peat mosses contain the trunks of the oak, pine, birch, alder, hazel, willow, and other trees, together with their seeds, fruits, and cones—apparently the wrecks of forests

* *Vide* "Gardener's Chronicle and Agricultural Gazette," of September 26th, 1857, in which Mr. Moore's report is published *in extenso.*

entangled and destroyed by the accumulation of the swampy peat, prostrated by storms or felled by the hand of man. And, what is deserving of special notice, the trunks of many of those trees are of most gigantic dimensions in districts where now the same species struggle on for a stunted and dwarfish existence. Bones and horns of the Irish elk, stag, ox, and other animals, are found in most of our British mosses, with occasional remains of human art, as canoes, stone axes, querns, flint arrow-heads, &c., of the British stone period; Roman weapons and coins that date to the first invasion of the island by the legions of Cæsar; and not unfrequently the skeleton of man himself. Some of these fossils are comparatively modern; others point to a period apparently coeval with the dawn of the human race."*

87. The growth of bogs in Ireland is very rapid, amounting, in peculiarly favorable circumstances, to a depth of two inches in one year, according to the experience of Sir Richard Griffith.†

88. We have upwards of 2,800,000 statute acres of bog in Ireland, the greater part being in one connected expanse. If a line were drawn from Wicklow-head to Galway, and another line from Howth-head to Sligo, the space between these two lines, which would occupy about one-fourth of the entire superficial extent of the country, would contain about six-sevenths of the bogs in the island, exclusive of mere mountain bogs, and bogs of no greater extent than 800 acres. The small bogs not included in the last tract are very numerous in some parts. In the county of Cavan there are about 90 bogs, not one of which exceeds 800 acres, but which collectively contain 17,600 acres. Most of the bogs which lie east of the Shannon, and occupying parts of the counties of Kildare and King's, are known by the name of the bog of Allen, a name not applied indeed to any one great bog but to several, separated by ridges of high country. The surface of the land rises very quickly from the bog of Allen on all sides, particularly to the north-west, where it is composed, to a considerable depth, of limestone gravel, forming very abrupt hills. In places where the face of the hills has been opened, the mass is found to be composed of limestone, more or less rounded, varying in size from two feet in diameter to less than one inch. They are

* In 1833, an ancient wooden house was found in Drumkilin bog, near the north coast of Donegal. The roof of the house was four feet below the surface of the bog, and it is thought to have been sixteen feet below the surface before any peat was removed. It was twelve feet square and nine feet high.

† It is not an unfrequent occurrence for bogs to burst out and suddenly cover large tracts. In 1835 such a phenomena occurred on Lord O'Neill's property on the Ballymena road, in the neighbourhood of Randalstown. On the 19th of September of that year, a rumbling noise was heard, as if under the ground, and immediately after the bog moved forward, exhibiting a broken and rugged appearance, with a soft peaty substance boiling up through the chinks. It remained in this state until the 22nd, when it again moved suddenly forward, covering corn-fields, potato-fields, turf-stacks, hay-ricks, &c. The noise made as it burst was so loud as to alarm the inhabitants, who, on perceiving the flow of the bog, immediately fled. It is said that upwards of 150 acres of arable land have been covered by this outbreak.

usually penetrated by contemporaneous veins of lidian stone, varying in color from black to light grey.

89. In the reclamation of peat efficient drainage should precede all other operations. And owing to the extremely great force with which this substance retains water, the effects of drainage are not so marked as we might be led to anticipate. Thus Schubler showed that ordinary soils retain about half their own weight of water—the lighter soil retaining less, and the heavier soil more of it. Pure humus retained nearly twice its own weight of moisture; while Dr. Anderson has shewn that peat of good quality, taken from the surface of a morass, was able to retain six times its own weight of moisture. It is quite evident, therefore, that in order to be efficient, the drainage of peat must be very effectually done.

90. In the subsequent process of reclaiming peat there are certain elementary principles which should be carefully observed—principles which though fundamental, have been little attended to, as is fully evidenced by many of the essays that have appeared on the subject from time to time. Owing to the air having been for centuries more or less excluded from peat, it contains a peculiar substance named tannin or tannic acid, which is always found under such circumstances, and which has the property of preserving vegetable substances like peat as well as animal bodies from undergoing decomposition. If the tannin be removed, or its antiseptic properties counteracted, the peat readily enters into active decay. Now, lime forms with tannin a soluble compound; and hence by the addition of the former to peat, the latter is washed out of the soil by the first shower of rain that falls upon it after its drainage; and the decay of the peat is at the same time induced, and its more rapid decomposition is subsequently promoted by mixing it with decomposing farm-yard manure, liquid manure, or any other manure containing nitrogen in an active state. Any of the lime that is not required to neutralize the tannin hastens the decay of the peat.

91. When there is considerable depth of peat, the most economical mode of disposing of it is as fuel.

92. When the underlying strata is of a clayey or calcareous nature, or when those materials are within reasonable distance of the peat, its reclamation can be economically effected. The peat itself contains all the elements required by our farm crops; but these elements are so locked up in the structure of the dead plants as to be unavailable. And besides, peat wants that stability which is essential for giving the necessary support to plants. There are, therefore, two obstacles to be encountered and removed, in order to convert peat into a fertile soil. We must render available the materials of which it is composed, and give it weight and firmness. In order to effect those desirable ends, it is usual to have resort to (1) burning the peat and (2) manuring it.

93. There is, in peat, an undue preponderance of organic matter,

and a corresponding deficiency of mineral matter; and the object of burning is to establish a proper equilibrium between these two classes of constituents. But to produce any decided change in the character of the soil, we must operate on a considerable bulk of it. Thus it has been shown that the uppermost ten inches of an acre of good arable land weighsat least 1,000 tons, which contains two or three tons of nitrogen, and 900 tons of mineral matter, of which from thirty to fifty are absorbable by plants, while the same depth of the peat referred to as having been experimented upon by Dr. Anderson, weighed only 100 tons per acre, and contained only four tons of mineral matter; so that even the complete burning of a layer of peat ten inches deep would go a very short way in converting a peaty soil into the condition of an ordinary arable one. At all events, it is quite apparent, that as a means of altering in any material degree the physical character of peat, we must not attach too great an importance to the burning of it : we must rather resort to other modes, such as claying, &c., for altering its mechanical condition, and burn occasionally, as a means of immediately rendering available a quantity of the mineral food stored up in the soil.

94. The application of clay to peat has been extensively and most successfully adopted. Numerous examples are recorded in the agricultural periodicals, and have come within the experience of every agriculturist. One of the most striking instances is presented to us in the peats in the south-west of Norfolk, and which vary from two to twenty feet in depth, and rest on a substratum of clay which is dug from the beneath the peat, even when the latter is twenty feet thick. The "border fenny peats, skirting higher ground have been improved by expensive dressings of clay, marl, chalk, and sometimes sand. Extraordinary dressings of these earths, viz., from one hundred to three hundred tons per acre, are applied, and a rush-growing morass has, by these means and by draining, been speedily converted into fruitful corn fields. Such dressings may be considered too much at once; but they are required to consolidate the peat, some of which is so light that on losing water it blows away."

95. Professor Tanner, in his report on the agriculture of Shropshire, gives at once the cause and the cure of peaty formations met with in parts of that county. "I attribute," he says, "the formation of those peats to springs rising from the old red sandstone rock, and carrying up a quantity of iron dissolved in the water, which, on being exposed to the air is thrown down and amalgamates with the particles of sand, producing a conglomerate mass, or moor-pan, from four to eight inches beneath the surface. The moist soil resting upon this produces aquatic plants and mosses, which, after many years, produce a bog or moss. By opening up this pan, we dry the bog, by producing an outlet for the water."*

* J. R. A. S. E., vol. xix. pp. 47-8.

We may, however, say with Mr. Sewell Read, that it is an almost hopeless task to attempt the reclamation of peat when neither clay nor marl is available. "There is no hope," he says, "of improving a poor peat eighteen feet deep resting not on clay, but on a rising sand." But when, as already remarked, clay or marl can be commanded, we may reasonably and confidently expect that peat can be reclaimed with a prospect of not only giving a remunerative return to the individual who is enterprising enough to invest in the work, but also of becoming of national importance in increasing the surface of land available for producing bread stuffs, and of vastly benefiting the laboring man, to whom the reclamation of the broad acres of our waste lands is an object of deep interest.

CHAPTER VI.

SOME PHYSICAL AND OTHER PROPERTIES OF SOILS.

96. Believing that too little attention is at present bestowed by practical men on the more important physical and other properties of soils, we conclude this Essay with a chapter on the subject.

We mean by the physical, as distinguished from the chemical, properties of soils, those external characters that are more or less apparent to the senses, and which practical men possessing no very profound knowledge of the physical sciences, can understand as certain, and turn to profitable account in the management of land.

97. The most important physical properties of a soil are:—1st, specific gravity; 2nd, state of sub-division of the particles; 3rd, adhesiveness; 4th, its power of absorbing and retaining moisture; 5th, its capillary attraction; 6th, the degree to which it contracts on drying; and 7th, its color and relations to heat. We will briefly consider each of those properties, and,

1st. Specific gravity of soils, by which we understand the weight of a given bulk of them, as compared with the same bulk of other bodies; water is taken as the standard for comparison. The specific gravity is ascertained by a common phial or bottle, capable of containing 3 or 4 oz. of water.—Counterpoise the bottlefull of water on a delicate balance, and then empty 1,000 grains of the water, after which introduce the soil (and the specific gravity is usually ascertained in the dry state) in the phial till the water rises to the level which it previously occupied, and the weight of the soil introduced is its specific gravity. This method is not perfectly correct, as not only is a portion of the soil dissolved in the water; but the latter

enters the pores of the former.* The per-centage of the soil soluble in water is, however, so very small, that the result is sufficiently accurate for practical purposes. Tested in this way, we find the soil of the Model Farm, Glasnevin, has a specific gravity of 2·25 (water being represented by 1), and the sub-soil 2·43. A very simple mode of ascertaining the weight of a cubic foot of soil in a dry condition, is to weigh an exact imperial half pint of it, and multiplying this by 150 (Johnston). According to this rule, we have found that on the 21st April, 1859, a cubic foot of the soil above referred to weighed 94 lbs. In this state its specific gravity would be about 1·5; and an area one foot deep would weigh 182 tons. Representing the weight of a cubic foot of siliceous sand by 1, a cubic foot of pure clay would be about 0·7. A cubic foot of peaty soil would be from 0·3 to 0·45. It is evident, therefore, that the specific weight of a soil enables us to form an opinion of the amount of sand or vegetable matter contained in it, and must not, therefore, be neglected by the land valuer.

98. The state of sub-division of the particles of the soil exercises considerable influence on its productive powers. The more we comminute the soil the greater the surface it presents for the absorption of the ammonia, &c., of the air; and the more effectually the air acts in rendering available its dormant mineral constituents. Some idea of the large surface presented by porous bodies may be formed from the fact, that a cubic foot of charred wood, the cells of which have been estimated at $\frac{1}{2400}$ of an inch in diameter, presents a surface of 73 square feet, available for the absorption of gases. Charcoal has been found to absorb thirty-five times its own bulk of carbonic acid—one-third of which is supposed to be condensed in the pores of the charcoal in a liquid state. The humus of the soil somewhat resembles charcoal in its action in absorbing gases; and clay, even when taken from a very great depth beneath the surface of the ground, has been found to contain a considerable quantity of ammonia.†

99. Dr. Kroker, one of Liebig's ablest pupils, has shown that soils contain a quantity of ammonia, compared to which the amount contained in an average crop of wheat or turnips, or in an ordinary dressing of manure, is insignificant. And Liebig himself has estimated that an acre of soil, to the depth of a foot, and assuming the specific gravity at 1·5,* contained

	Ammonia per acre.
From the garden attached to his own house .	22 960lbs.
From a wood in the vicinity	20 910lbs.

* Owing to its porosity, Liebig diminishes the specific weight of a soil examined by him from 2·25 (ascertained as above recommended) to 1·5. Making this reduction in the specific gravity of the soil of the Model Farm, a cubic foot of it, in a dry state, weighs about 95lbs.

† A subsoil of tertiary drift four feet beneath the surface contained two cwt. of ammonia per acre, equal to 12½ cwt. Peruvian guano.

A tobacco soil from Cuba, never manured, contained per acre 14,350th of ammonia. Liebig's has also shown that "clay, alumina, and peroxide of iron, all of which are present in the most fertile soils, possess a most remarkable power of absorbing ammonia from the air," and contends that as fertile soils have the power of absorbing ammonia from the air in such abundance, this substance may be partially if not wholly dispensed with in manures.

100. In practice, however, it is found that remunerative crops cannot be raised, even off land containing in its pores a large quantity of ammonia with non-nitrogenized manures. We find, for example, that the soil of the Model Farm as analysed by Dr. Hodges contains 0.29 per cent. of nitrogen, equivalent to 0·35 per cent. of ammonia, which gives 1436½lbs. ammonia per statute acre, or about sixteen times the quantity contained in about 5 cwt. Peruvian guano, the most concentrated ammoniacal manure we possess; and yet on the same soil ammonia, as an ingredient of manures, cannot be dispensed with. We are, therefore, forced to conclude that the ammonia naturally present in soils is not all in an available state for ministering to vegetable nutrition; or as Way suggestively asks, "is it too tightly locked up in the soil?" If we answer in the affirmative, it is very important that we should discover a key that would loosen the vice which grasps it. Now, Way has demonstrated that in the presence of water lime sets free from the soil, as nearly as possible, one half of the ammonia; and, it is, to say the least of it, a question which concerns the practical man, if a moderate application of lime, which would cost very little, would not in such a case have a better effect on heavy soils than a costly application of ammoniacal manures in the shape of guano.*

The remarks just made show, at all events, the great importance of thoroughly pulverizing the ground, by which we increase its power of absorbing ammonia from the air, the increased absorption being in proportion to the state of sub-division to which the soil is reduced, and the frequency with which the air in its pores is renewed.

101. The adhesiveness of the soil concerns the practical man, so far as it enables him to judge of the support it is likely to give plants, as well as the amount of motive power expended in drawing the various implements of tillage through the soil. This property depends upon the constitution of the soil; thus clay causes a greater draught than sand: while a sandy soil, when moist, offers a resistance to the passage of agricultural implements through it of four or five lbs. to the square foot of surface, clay gives a resistance of from 8lbs. to 20lbs. to the square foot.

102. The power of absorbing and retaining sufficient moisture to

* J. R. S. A. England, Vol. xv., p. 512.

meet the wants of vegetation is one of the properties which give fertility to soils. It is well to distinguish(*a*) the power of absorbing moisture from the air, from(*b*) the property of retaining water.

a. As regards the power of absorbing moisture from the air, it may be remarked that it has been found that the rain is not adequate to afford moisture enough for the growth of crops ; the moisture abstracted from the air, and condensed within the pores of the soil, being an essential source of conveying nourishment to plants. Thus, if we assume the rain's fall at thirty-six inches, and that one-third of this, or about 3,000,000lbs. per acre, becomes the vehicle for carrying food into plants, and assuming the water to have the composition of the drainage waters examined by Way, a crop of potatoes, *e.g.*, would receive from a hectare (2½ statute acres) of four of the fields whose drainage waters were analyzed, not a single pound of potash ; from a hectare of two other fields somewhat more than one pound; and from a seventh hectare 2lbs. of potash, while a crop of potatoes yield per hectare 200lbs. potash. Liebig argues from facts like these that plants themselves, as organized beings, perform a part in appropriating food directly by their roots, without that food being in solution. Instead of at present accepting this theory, let us rather seek an explanation of the discrepancy between the quantity of mineral matter which rain water may carry into plants, and the quantity of this matter found in the ash of plants, in the large amount of moisture which we know soils abstract from the air, and condense in their pores.

103. Sir Humphrey Davy, the father of modern agricultural chemistry, has been censured for promulgating an idea which he entertained; namely, that the fertility of soils depended upon the property of absorbing moisture from the air. Now, while we would not accept the general deduction of that immortal pioneer (for peat and unmanageable clays possess the power of absorbing the moisture in an eminent degree), yet we are of opinion that this property has been too much neglected in our own day.

Davy found that all fertile soils possess the property under review in a very high degree. Thus, when made perfectly dry, he found that 1,000lbs. of a

Dry fertile loam from East Lothian gained in one hour,	18lbs.	moisture.
,, ,, from Somersetshire,	16	,,
Soil from Mersea, Essex, worth 45s. per acre,	13	,,
Sandy soil from Mersea, Essex, worth 28s.	11	,,
Coarse sand, worth only 15s. per acre,	9	,,
Soil of Bagshot Heath,	8	,,

The following table gives the moisture absorbed by 1,000 grains of dry earth on a surface of 50 square inches in 72 hours.

	Grains.
Siliceous sand,	0
Powdered gypsum,	1
Calcareous sand,	8
Arable soil,	23
Sandy clay,	28
Slaty marl,	33
Loamy clay,	35
Fine lime,	36
Stiff clay,	21
Pure grey clay,	49
Garden mould,	52
Fine magnesia	82
Humus,	120

In order to ascertain the power possessed by a soil for absorbing moisture, spread on a common saucer or small plate 1,000 grains of the thoroughly dried earth, and place on it a flat-bottomed dish containing some water, and invert over it a wide jar, and after having stood in a room protected from the sun for twenty-four hours, the increased weight will show the amount of moisture it is capable of absorbing. (Hodges.)

104. *b*. The degree of cohesive force with which the soil retains water is also very important, and is readily ascertained by putting 1,000 grains or so of the dry soil in a funnel having a double " filter," and pouring water gently upon it until the latter begins to drop from the funnel, when the increased weight of the earth shows the degree of moisture the soil is capable of retaining. It has been found that water begins to drop, in this way, from 100lbs. of

Quartz sand,	when it has absorbed	25lbs.	water.
Calcarious sand,	"	29	"
Loamy soil,	"	40	"
English chalk,	"	45	"
Clay loam,	"	50	"
Pure clay,	"	70	"
Surface soil of the model farm,*		69	"
Subsoil,*	"	48	"

The warmer the climate the more the value of the soil is enhanced by its power of absorbing and retaining moisture; but where rain falls in heavy and frequent showers it is not desirable that a soil should possess the property of retaining moisture in a very high degree. For instance, we know that clay and peaty soils retain the greatest quantity of rain water; but owing to the loss of heat in evaporating it, this very property renders them the coldest soils in cultivation.

105. Every school-boy knows the nature of capillary attraction; but farmers are always aware of the great importance of the capillary action of soils. As the rain water sinks and accumulates in the subsoil, it rises again through the capillary openings in the soil,

* Of the water thus absorbed the surface soil lost by evaporation in four hours 1·8, and the subsoil 3 per cent.

as water rises in a sponge; and "hence, when there is an access of water in the subsoil, for want of drainage, &c., this capillary action keeps the soil always moist and cold."

Sandy soil, and such as contain much vegetable matter, being most open and porous, possess this property in the highest degree. Professor Johnston maintains "that in sandy soils, and generally in all light soils, of which the particles are very fine, this capillary action is intimately connected with their power of producing remunerating crops. These soils absorb the falling rains with great rapidity, and these carry down the soluble matters, so that when the soil becomes soaked, and the water begins to flow over its surface, the saline matter being buried deep, is in little danger of being washed away. On the return of dry weather, the water reascends from beneath, and again diffuses the soluble ingredients through the upper soil." *

106. In drying, all soils, except sand, shrink or contract; and the more clay or vegetable matter a soil contains, the more it swells by saturation with water, and the more it contracts on drying—the more it swells and shrinks in changes of wet and dry weather. The great contraction that takes place in strong clays exercises an injurious effect on the tender roots of plants; while, in medium soils, the compression is more uniform, and the roots are enabled to throw off new shoots in all directions.

According to Schühler, 100 parts of—

Silicious sand shrinks, in drying,	nothing,
Sandy clay,	6 parts
Loamy clay,	8·9 „
Brick clay,	11·4 „
Grey pure clay,	18·3 „
Garden mould,	14·9 „
Arable soil,	12·0 „
Humus,	20·0 „

107. It is established beyond all doubt that the progress of vegetation is in direct proportion to the heat of the medium in which the plants are placed. Look at the difference between the vegetation of the torrid, and temperate, and frigid zones; all traceable to the difference in temperature. Look to our hot-houses, in which, by increasing the heat, we grow plants natural to warm countries. And in the open fields a difference of a few degrees between the temperature of the summer months, in two consecutive years, affects the produce to a wonderful, often to a calamitous extent. Now, as different soils possess very different powers of absorbing and retaining the heat of

* The saline incrustations seen on the surface of the soil in summer are caused by the rising, in this way, from beneath, of the water, each particle of which brings with it a particle, however small, of saline matter, (for such waters are never pure,) which remains behind when the water is evaporated. Large crusts found in this manner are to be seen, in dry seasons, in Greece, Egypt, India, and many parts of Africa and America. (See Johnston's Lectures, p. 536.)

the sun's rays, it is very important to study the relation of soils to heat.

108. Let us premise two axioms:—1st, that all bodies (soils included) which absorb heat most speedily, part with it by "radiation," as it is called, most readily when exposed to cold; 2nd, that dark-coloured bodies (soils also included) absorb heat most rapidly—in other words, the lighter in color a body is, all other things being the same, the less heat it absorbs.

109. It is evident, then, that the color of soils exercises an important influence on their value. It is found that brown and reddish soils acquire comparatively high degrees of temperature, and are considered warm. Yellow, pale, and bluish gray, comprising most of the argillacious soils, are cold. Yellowish grey, dull red and dull brown are little altered in color by ordinary cultivation and manuring; while yellowish, bluish, and bright red soils become darker by culture by this means. Black and brownish soils attain a temperature from 3° to 8° higher than soils of light color. While the thermometer stood at 77° in the shade, in August, Schühler found sand of a natural (light) color, indicated a temperature of 112½°; white sand, 110°; and black sand, 123½°. It is worthy of remark that with surfaces of the same color, Schühler found that the materials composing the soils made little difference in its capacity to become heated, provided they were in the same states as to dryness; sand, clay, loam, garden-mould, &c., showing very little difference with the thermometer!

110. We cannot fully agree with Schühler that the material composing the soil makes little difference in its relation to the absorption and retention of heat. It has been found that the mean temperature of the clay slate in Cornwall is nearly 4° higher than that of granite—a result which can scarcely be owing to difference in color alone.

111. In passing through the air the calorific rays* of the sun suffer considerable diminution. The loss has been variously estimated from 19 to 41 per cent. as it reaches the surface. Had the sun's heat not been felt at all, it has been estimated that the temperature of the surface of the earth would throughout be uniform at —128° F.

112. Independently of the color of the surface, the amount of heat which the sun imparts is in proportion to the perpendicularity of its rays. Taking the loss of radiant heat in its vertical passage through the air at only 25 per cent., at an angle of elevation of 25°, the original force of the sun's rays would be reduced to one-half, and at an angle of 5°, to one-twentieth.

113. There is always a great difference between the temperature of

* The sun's rays possess calorific or heat-giving properties; 2nd, luminous or light-giving properties; 3rd, chemical properties, or power to induce chemical changes; 4th, the power of inducing phosphorescence.

the soil and surrounding air. In our British summers the temperature of the soil rises to 110°, and sometimes to 150°, while the air in the shade is between 70° and 80°. This is a most important circumstance; the increased temperature acquired by the soil directly stimulates vegetation, and promotes the decay of the constituents of the soil.

And, again, in cold weather, the temperature of the air at the height at which thermometers are usually kept (four or five feet), is greater than at the surface. This arises from the effects of radiation and evaporation. Thus Dr. Jamieson found at half-past P.M. the thermometer in the air stood at 31·3 F.; on snow, 18·2.

114. In inquiries of this kind, it is important to compare the conditions of the mere surface-soil with what lies beneath, as there are diurnal and annual variations of temperature; the former are not considered to extend to a greater depth than about three or four feet; the latter cease at from 65 to 80 feet.

"The soil," says Sullivan, "to a depth of about three feet and a-half, is subject to all the changes of temperature which take place in the air, not even excepting the diurnal variation of temperature; but the time of maximum and minimum temperature in the soil at the depth of a yard takes place from six weeks to two months later than in the air. Below the depth of four feet the temperature remains almost constant; in fact, the temperature at that depth may be considered as the mean animal temperature of the place."

Leslie made experiments in reference to this point, of which the following table gives a summary:—

Depth of Thermometer.	Maximum Temperature during three year.	Minimum Temperature during three years.	Range during three years.
Feet.	Deg. F.	Deg. F.	Deg. F.
1	58·	33·	25·
2	56·	54·	20·
3	54·	39·	15·
4	51·5	42·	9·5

The experiments were made in a gravelly soil, which turned into a quicksand at four feet deep. During the three years the frost did not penetrate one foot into the ground.

Professor Forbes, of Edinburgh, found the annual range of temperature at a depth of three to two feet to vary in different strata as follows, being a mean of three years:

	Deg. F.
In trap tufa, ...	17·41
In loose sand, ...	19·85
In compact sandstone, ...	17·41

For an equal change of temperature to be sensible to a depth of one foot 7·5 days are required in case of trap tufa, 7·1 days in loose sand, and 4·9 days in compact sandstone.

M. Quetelet, of Brussels, gives the results of his observations from 1834 to 1837:—

Depth in English Measure. Ft.	In.	Annual range. Deg. Fah.
0	7½	23·90
1	6	22·39
2	6	20·43
3	3	19·04
6	5	13·66
12	10	8·08
25	7	2·03

Josiah Parks made some interesting observations on the temperature of the red moss of Lancashire, some of which are recorded in his essays on drainage. The depth of the bog where the observations were made was nearly thirty feet; and it was found that its temperature, from a depth of twelve inches downwards to the bottom, was uniformly 46°. F.

115. It has been said that those soils which absorb heat most rapidly part with it most freely. Taking for illustration three soils, it has been found that a peaty soil cools as much in one hour and forty-three minutes as the same bulk of clay in two hours ten minutes, or of sand in three hours thirty minutes. Hence, another reason why sandy soils are warm; and remain so for a longer time after the sun sets. "But on soils which cool the soonest, dew will first begin to be deposited; and it is doubtful, when the soils are equally drained, whether, in summer weather, the greater proportion of dew deposited in the clays and vegetable moulds may not more than compensate for the less prolonged duration of the elevated temperature derived from the action of the sun's rays" The earths possess the power of retaining heat nearly in proportion to their specific gravities.

116. Though the foregoing consideration on the physical properties of soils are based on scientific data, yet they are not without practical value, as they make us acquainted with laws which may be made subservient to increasing the productiveness of a soil. We know that famine is often produced when the summer temperature falls short of that degree of heat which is essential to bring our cultivated crops to maturity; and even a difference of a degree or two in our summer temperature may seriously affect the interests of mankind.

117. Now, there are several means by which the practical farmer may increase the temperature of his soil to a degree which will enhance its value. The addition of farm-yard manure, peat-mould, soot, and all dark colored substances to light colored soils, increases their power of absorbing the heat of the sun's rays; and applications of sand gives to a soil greater power of retaining the temperature which it requires.

The occasional mixture of soils, therefore, when it can be done ecconomically, is a practice to be commended. As a general rule it may be stated that we can render light-colored soils darker in tint, and consequently warmer by cultivation, laying them down to grass, and by applications of the manures already named.

Perhaps it may be well to explain that my object in writing this Essay has been, not to instruct professional agriculturists, or those farmers who may have made agricultural chemistry a study, but to put forward, in a plain and popular style, certain views that are not, in my opinion, as generally known as they deserve; and to throw out matters which are entitled to the serious consideration of practical men.

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4th „	½ Phospho-Peruvian Guano, half Gibbs,	„	24	5		
5th „	Phospho-Peruvian, alone,	„	24	11	3	

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An interesting feature in the New Journal is its News Department, in which will be found an ample and correct summary of the Week's News—Foreign and Domestic. Arrangements have been made by which the Latest Intelligence by Telegraph is received at the *Review* Office immediately before publication.

Whilst the pages of the *Weekly Agricultural Review* will be open to fair and legitimate discussion and criticism, everything personal, or in which the general reader would not be likely to feel interested, shall be strictly excluded.

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DUBLIN MANURE COMPANY'S OFFICE,
20, USHER'S-QUAY, DUBLIN.

THE DUBLIN MANURE COMPANY beg to call attention to the fact that the high price of Guano, its constant adulteration, and the *impossibility* of any one distinguishing, by the unaided senses, *adulterated* samples from the genuine Peruvian, together with its evanescent effect on the soil, renders the use of a more permanent Manure a matter of necessity:—nearly all the Artificial Manures in use have been IMPORTED at a *greatly increased outlay* on the *first cost*, to cover transit and other charges.

The DUBLIN MANURE COMPANY has been established in order to put an end to a system so anomalous, and to apply the recent improvements in Agricultural Chemistry to a commercial undertaking on a large scale. With this object, Steam Engines, Vitriol Works, and powerful Machinery have been erected to manufacture ARTIFICIAL MANURES of all kinds.

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BY THOMAS BALDWIN,
Lecturer on Agriculture.

THIS little volume gives a concise notice of the varieties of crops cultivated, the implements used, &c. It also contains full particulars as to the admission of pupils, including the programme of entrance examination.

It is illustrated with a map of the farm, and a ground plan of the farm offices.

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HOWARD'S PRIZE IMPLEMENTS, 1859.

	£	s.	d.
P. Plough, with Two Wheels (for Light Work), . . .	4	7	6
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Beg to direct attention to their Prize Implements, which are Sold in Ireland.

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PATAGONIAN GUANO—1859.

6, NEW QUAY, LIVERPOOL, FEB. 24TH.

WE believe that the Patagonian Guano has now become so generally known and appreciated for its fertilising qualities in the growth of tunips, mangel, rape, potatoes, and other bulbous crops, that we conceive it unnecessary for us to make any lengthy remarks on this manure. In the year 1853 we purchased the island from which we obtain it, and have imported and sold since that time about 10,000 tons. We find the demand annually increasing, and we have therefore made arrangements for a considerable quantity this season. Four years ago we sold it at prices varying from £8 to £10 per ton; we have since reduced it to £6 10s. per ton ex-store in bags; the only profit we look for being a return freight for our ships. We have sold our importations principally in Scotland and in the North of England, where it is most favorably known; but in the spring of last year we sold some trial lots in the North of Ireland, and *annexed* we give the reports we have obtained from the parties who used it. These must speak for themselves. The most important trial is that of Allan Pollok, Esq., of Lismany, County Galway, who used 100 tons. This gentleman farms the enormous breadth of 30,000 acres on the Scotch system, and is one of the most intelligent and practical agriculturists in the kingdom; he is, therefore, well qualified to give a sound opinion. We would also call especial attention to the report of Thomas Thomson, Esq., of Millfield, Kelso, taken from the *North British Agriculturist* of the 10th November, 1858. Mr. Thomson has used the Patagonian Guano for four years consecutively. This guano has succeeded so admirably in Cumberland, where we sold extensively last season, that one gentleman, a Mr. Bruce, who took only five tons, has now ordered thirty tons for 1859.

After all these practical and satisfactory experiments made by the first agriculturist in the kingdom, we have no hesitation in giving the Patagonian Guano our strongest recommendation as a cheap and valuable manure for root crops. It contains a large proportion of organic matter and Phosphates of Lime. We obtain it from the deep gullies and fissures in the rocks on the island, resorted to by innumerable flocks of Penguins and other aquatic birds, which are continually adding fresh deposits We take great care in its collection, and we are prepared to give any amount of guarantee that the article is pure and genuine as taken from the pits, and importations are coming direct to Ireland.

The Patagonian guano contains a most peculiar quality, which chemists have hitherto been unable to explain, namely, that it rots the bags in fourteen days.

We have appointed

MESSRS. DAVID ROGERSON AND CO., OF DUBLIN.

Sole Agents for Ireland, and their great respectability will be a sufficient guarantee that they will supply it in the same state of purity as when received from the ship's side. Any parties desirous of obtaining sub-Agencies for the sale of our Guano in Ireland will please apply immediately to these gentlemen.

H. C. SMITH AND CO.,
IMPORTERS.

P.S.—According to Mr. Pollok's plan the following saving is effected:—

	£	s.	d.
Use, say two-thirds, or 2 tons Peruvian, at £14 . .	28	0	0
And one-third or 1 ton Patagonian, at £6 10s . . .	6	10	0
	£34	10	0
If three tons Peruvian alone were used it would cost . .	42	0	0

Thus saving in three tons £7 10s., or exactly £50 on every 20 tons.

TESTIMONIALS IN FAVOR OF PATAGONIAN GUANO, 1858.

Letter from Allan Pollok, Esq., of Lismany, County Galway:—"Patagonian Guano (100 tons of which I used last year) is an excellent manure for either Turnips or Rape, and I have good crops from it applied by itself, but I consider it better to apply it in conjunction with Peruvian, in the proportion of about one-third Patagonian and two-thirds Peruvian, which gives *better crops* than when the whole was Peruvian." Mr. Pollok has this season (1859) taken another 100, tons.

Thomas Thomson, Esq., Millfield, Kelso, writes in the *North British Agriculturist* of 10th November, 1858 :—" A few days ago I pulled and weighed the experimental plots

among my Turnips, with the following results"—("My crop as excellent as the results show—they are the best in the district"):—

TRIAL No. 1.

"The Manures were applied as costing 45s per acre, at the nearest railway station.

	Tons.	Cwts.	Qrs.
Bolivian Guano,	25	0	3
Valparaiso do.	23	6	0
PATAGONIAN do.	22	10	0
Peruvian do.	22	10	0
Californian do.	20	7	0
Dissolved Bones,	20	7	0
West Indian Guano,	19	8	2
Rape Dust,	19	8	2
B. Bones (dissolved),	19	3	0
Dissolved Bones (from Berwick),	19	0	1
Upper Peruvian Guano,	18	4	1
Mexican do.	18	4	1
Ammoniacal Dissolved Bones,	16	12	0
Patent Wood Manure,	14	12	0
Sawdust Steeped,	10	15	0

TRIAL No. 2.

"In the following trials, I used half Peruvian guano, and half each of the manures noted, that is, 22s. 6d. worth of each per acre, the total cost being 45s. per acre, as in trial No. 1:—

	Tons.	Cwt.	Qrs.
Peruvian and Patagonian Guano,	25	17	0
Do. and Dissolved Bones,	25	8	0
Do. and West Indian, Guano,	23	16	3
Do. and Steeped Sawdust	23	8	3
Do. and Upper Peruvian Guano,	23	15	0
Do. and Patent Wool Manure,	21	0	0
Do. and Californian Guano,	19	3	0
Do. and Mexican do.	18	7	0
Do. and Rape Dust,	16	12	0"

We give Mr. Thomson's report *in extenso*, as he has used the Patagonian Guano for four years consecutively, and has taken great care to arrive at results. Last year he took thirty tons, and has promised to take his supply for the present year.

James Murray, Esq., Drumbanagher Castle, near Newry, writes, September 21, 1858:—"As to the manurial proprieties of your Patagonian Guano, I must say it has given me great satisfaction, and I believe its value to *Turnip Growers* very great, when scarcity of Farm-yard Manure occurs, as is too often the case. Half Farm-yard Manure was my method, with 3 cwt. of your Guano; and I never had a better appearance of Swedes than I have at present."

Snowden Corken, Esq., Lisburn, Ireland, says:—"Your Patagonian Guano succeeded admirably with me. I used it with Turnips and Mangolds this season; it appears to do very well with root crops; I shall use it again."

William Graham, Esq., Lisburn, Ireland, says:—"My crop is very good, and I shall not hesitate to use more of the Patagonian Guano; I consider it good value at the price."

Wallace Legge, Esq. Malone House, near Belfast:—In 1857, he took half a ton; in 1858, 6 tons, and he has this year orderod 8 tons; he writes, that the trials he made were very satisfactory.

Joseph Taylor, Esq., Hope Cottage, Wavertree, near Liverpool, writes:—"1st November, 1858:—Messrs. H. C. Smith & Co., Gentlemen—In the Spring of this year I had a bags of your Patagonian Guano, ex 'Water Witch.' and at the same time I had a few bags from another party, represented to be 'Peruvian.' I put equal quantities of each sort to each neighbouring drill of Potatoes, Mangels, and Turnips, and I am pleased to say that they did very well on both sorts, but certainly the Patagonian Guano produced the best Mangels, indeed they were the best I ever had, weighing 18lbs. On the Turnips I could not see any difference to speak of. The potatoes on yours were also good, but from some cause, which I cannot explain, the Potatoes on the Peruvian were almost worthless."

Extract from *North British Agriculturist*, dated Edinburgh, 30th December, 1857.—"At a numerously attended Meeting of the Western District of Mid-Lothian Agricultural Association, held at Mid-Calder, on Tuesday, the 1st December, PETER M'LAGAN, jun. Esq., of Pumpherston, in the chair, the following able paper on the 'Manures best suited for the Turnip Crop' was read by Mr. ROWAT, of Currievale:—'This season I had a trial of seven different lots, manured as follows—all per Imperial Acre:—

'Weight of Turnips per Im. Acre.	Tons.	Cwt.	Qrs.
'No. 1. Manured with 6 cwt. Peruvian Guano,	26	19	0
'No. 2. Manured with 6 cwt. Patagonian Guano, cost about 10s.	26	13	0

'In making a calculation of the costs of various Manures used in these experiments, *Patagonian* produced the largest weight of Turnips, for the money cost, but inferior Guanos are not to be depended on, *with this exception*.'"

GRASS SEEDS FOR PERMANENT PASTURE.

DICKSON, HOGG, AND ROBERTSON,
SEED MERCHANTS,
No. 22, MARY-STREET, DUBLIN,

INVITE the attention of Agriculturists to their mixtures of Grass Seeds for *Permanent Pastures*, &c., and to the scale of charges for the different mixtures, for particulars of which see page 12 of their *Descriptive Priced Catalogue of Agricultural Seeds,* which will be forwarded *post-free,* on application.

D., H., and R. have for many years made the *sowing down of land to meadow and pasture* their particular study, with a view to produce, in the *shortest possible time,* an herbage in every respect equal to the *finest old pastures,* due attention being paid to the following important objects, viz: *earliness, bulk of produce, nutritive qualities, reproductiveness,* and *permanency.* The different kinds of Grasses used in these mixtures being all collected separately by *the hand,* and afterwards *thoroughly cleansed,* D., H., and R. are enabled to apportion those kinds only which they have found during upwards of thirty years' experience best suited to various soils and situations.

Orders describing the nature of the *soil* and *subsoil* of the field to be laid down, will be carefully executed, with a suitable mixture.

☞ All orders amounting to £2 and upwards will be delivered, free of carriage, at the Railway Station.

PHOSPHO-PERUVIAN GUANO.

GUARANTEED EQUAL TO ANALYSIS.

MESSRS. PURDON beg to call attention of Agriculturists to the above admittedly valuable Manure, which, from the results of numerous experiments conducted by thoroughly scientific and practical farmers, has been proved to be better than any other manure tried in competition with it. In many instances gentlemen who took it solely on their recommendation last year have, from their own experience more than doubled their orders the present year. Analyses, testimonials, and terms may be had from

MESSRS. PURDON, BROTHERS,
SOLE AGENTS FOR IRELAND,
23, BACHELORS'-WALK, DUBLIN,
Who can forward it to any part of Ireland, in any quantity.

☞ CAUTION.—Understanding that some unprincipled parties offered for sale, last year, a spurious Phospho-Peruvian Guano, and that it is not unlikely a similar attempt may be made this year, Messrs. Purdon feel it their duty to inform the Farmers of Ireland that *none is genuine* except that supplied by them or their Agents, in bags, branded.

☞ Beware of spurious imitations or advertisements written in a style calculated to deceive.

Printed by J. M. O'TOOLE, 13, Hawkins'-street, Dublin.

✓

AGRICULTURAL ESSAYS.

BY

THOMAS BALDWIN,

Lecturer on Agriculture, Albert Institution, Glasnevin.

No. 2.

MANURES.

DUBLIN:

WILLIAM ROBERTSON, 23, UPPER SACKVILLE-STREET.

LONDON: SIMPKIN, MARSHALL, AND CO.

EDINBURGH: JOHN MENZIES.

1860.

PRICE SIXPENCE.

physiologists. The views entertained on the subject at present by men whose opinions deservedly command respect may be reduced to a few intelligible heads—

1st. That plants derive all their organic constituent elements (carbon, oxygen, hydrogen, and nitrogen) from the air.

2nd. That they derive them partly from the air and partly from the soil.

5. The state of combination in which the organic elements administer to vegetal nutrition is also a disputed point. Some, with Liebig, maintain that carbonic acid, water, ammonia, and similar mineral combinations of the organic elements,* are the only state in which plants can assimilate these elements; while many distinguished physiologists are of opinion that the organic compounds of the soil (humic acid, &c.), already described, become the food of plants. Whichever of these theories be the correct one, it is quite certain that as carbon is a solid substance, and insoluble in water, and as hydrogen (a gas twelve times lighter than common air) does not exist in nature in a free state, these two elements must, when taken up by plants, be combined with other substances. Oxygen and nitrogen exist in the atmosphere in a gaseous and uncombined state.† It has been proved that the former is inhaled by the leaves of plants under certain conditions. Nitrogen may be absorbed in the same way; "but if so, it is in very small quantity, and the fact of its being absorbed at all is very uncertain" (Johnston). These two bodies may also enter into plants, in their elementary state, in solution in water, but as they are very sparingly soluble, the quantity so absorbed must be exceedingly limited.

6. Liebig holds‡ that "plants in general receive their carbon and nitrogen from the air—the carbon in the form of carbonic acid, the nitrogen in that of ammonia; that the water and ammonia yield to plants their hydrogen; that the ammonia which is contained in, or brought by means of rain, &c., into, the soil, acts the part of a constituent of the soil; and that this is true, likewise, of the carbonic acid in the soil." In another place§ he teaches "that *the food of plants consists entirely* of inorganic materials; that carbonic acid, ammonia, and water are inorganic

* As the words organic and inorganic, as applied to soils and manures, have often led to mistakes, we may explain that the term organic, strictly speaking, is applicable to substances in which we can trace a living structure. Substances produced by living organs, such as starch, sugar, &c., are also regarded as organic. "The solid rocks, the incombustible part of soils, the atmosphere, the waters of the seas and oceans, everything which neither is nor has been the seat of life, may generally be included under the head of inorganic matter"—(Johnston).

"It is true that chemists sometimes speak of the organic food of plants, meaning thereby carbonic acid and ammonia. But this, which is not a strictly correct mode of expression, has reference, not to the *nature* of these substances, but to their *origin*."—Note by the Translator to Liebig's Memoir; Jour. Roy. Agric. Soc. England, vol. 17, page 316.

Carbonic acid, ammonia, &c., may, therefore, for the sake of popular distinction, be styled mineral combinations of the organic elements, as in the text.

† According to Dumas, 100 volumes of pure air consist of—

Oxygen	.. ..	20·90
Nitrogen	.. ..	79·10

There are several other substances generally present in the air; *e.g.*, 5,000 gallons of air contain about 2 gallons of carbonic acid (Hodges). 1,000 volumes of air contain, on an average, 8 volumes of watery vapour (Anderson). If all the carbonic acid and ammonia dispersed throughout the atmosphere were collected in one stratum around the earth, and possessed the same density as at the surface of the sea, the layer of carbonic acid would be a little more than eight feet high, and the ammonia less than a quarter of an inch (Liebig). Nitric acid, carburetted hydrogen, and ozone (the name given by Dr. Schönbein, of Basle, to the substance produced by passing electricity through dry oxygen gas), exist in the air in variable, but always in very small, quantity.

‡ Principles of Agricultural Chemistry; propositions 1 and 8.

§ Jour. Roy. Agric. Soc. Eng., vol. 17, p. 315.

compounds in the growth of plants; the hydrogen comes from the water, the carbon from the carbonic acid, the nitrogen from the ammonia." If these views be correct, the elements of the organic matter of the soil and manures must be resolved into mineral combinations—carbonic acid, ammonia, and nitric acid—before they can become the food of plants.

7. On the other hand, the late Professor Johnston, the most cautious expounder of agricultural chemistry, "considered it to be satisfactorily established that, while a plant sucks in by its leaves much carbon in the form of carbonic acid, and, perhaps, also some of the same gas by its roots, it derives a *variable* portion of its immediate sustenance (of its carbon) from the soluble organic substances—humic, ulmic, and geic acids—that are within reach of its roots." In support of this view of the case, it has been urged (1) that when plants are made to grow in infusions of madder, the radicle fibres are tinged of a red colour. (2) Sir Humphrey Davy* found that plants of mint grew vigorously in weak solutions of sugar, gum, jelly, the tannin principle, &c. Now, that plants do take up the soluble organic compounds of the soil has been placed beyond dispute; but it has not been equally well established that the plants assimilate their carbon or hydrogen. It is well known that copper, lead, &c., have been taken up by plants; but their presence in vegetable tissues is regarded as simply accidental.

8. Liebig's theory, which reduces vegetable nutrition to a very simple law, is totally opposed to the assimilation of humus by plants. This substance is neither inorganic nor organic, but is, as Professor Cameron† well observes, arrested half way between the two conditions. In this respect it may be compared to alcohol or acetic acid; and it is just as reasonable to expect the latter to supply carbon and hydrogen to plants as the former. Dr. Cameron has made some exceedingly interesting experiments, which have added fresh interest to this subject. He found that plants are incapable of effecting the decomposition of carbonic oxide (which is a less oxidized substance than carbonic acid) and cyanogen gas; and from these experiments he concludes, with much reason, that substances capable of being used as food by plants must be either in a perfectly oxidized (or *teleoxidic*) state, or in their natural static condition; and that vegetable secretions, such as gum, starch, &c., or the partially altered substances which formed their tissues, such as humus, are as unfitted for building up the vegetable fabric as urea, ammonia, carbonic acid—products of zoödynamic action—are incapable of repairing the waste of the animal tissues.

9. The operations of nature are all governed by indelible laws. The forces by which vital agency produce the marvels of animated life are never wasted, but are applied with the most exquisite harmony and the most nicely-balanced economy. That the food of animals must consist of organized matter is almost universally admitted, and that the food of plants should belong to the inorganic or mineral kingdom is a conclusion not only legitimate in itself, but is supported by analogy and reason. Modern agricultural research tends to the same conclusion. Liebig believes,‡ and the late Mr. Pusey has practically proved,§ that nitric acid—a mineral combination of two organic elements, nitrogen and oxygen—can replace ammonia as a source of nitrogen. And there is every

* Lectures on Agricultural Chemistry.
† *Agricultural Review*, November, 1858.
‡ Principles, p. 20.
§ Jour. Royal Ag. Soc. Eng.

reason to believe that urea, a substance composed of the four organic elements, and which must be regarded as inorganic, as it may be artificially prepared, can directly afford nitrogen to plants without being converted into carbonate of ammonia,* as was formerly believed.

We recognise in all this confirmation of the views we entertain on vegetal nutrition, and of the beauteous consistency of nature in reducing her kingdom to physical laws, which man can comprehend, and adapt to the requirements of his fellow men.

10. Having considered the mere form of chemical union in which the several organic elements are assimilated by plants, we proceed to notice with as much brevity as possible the sources whence they are derived. And here, it must be confessed, we are entering upon the most disputed question connected with the growth of our farm crops—a question which we cannot discuss without bringing under review the controversy between Baron Liebig and his disciples on the one hand, and Mr. Lawes, of Rothamstead (England), and several distinguished scientific men and practical agriculturists on the other. The difficulty, too, of arriving at a satisfactory conclusion on the subject is vastly magnified by the voluminous evidence on either side, and the acrimony with which arguments have been occasionally tinged. It is, therefore, with extreme diffidence that we venture to approach a topic on which men of comprehensive minds appear to have failed in convincing each other; and our only apology for doing so is, the intrinsic importance of the entire subject to British agriculture.

11. That plants can grow in a soil free of organic matter is a fact well known to every person who has any acquaintance with vegetation. The earlier vegetables probably grew in soil free from organic matter. We daily see plants strike root in the solid rock; and direct experiments prove that our cereals can grow in soils which contain no organic matter. Many have concluded from facts like these that if the ash constituents of plants are present in the soil in sufficient quantity, and in available form, the nitrogen and carbon required by the plants will be supplied by the atmosphere. Several passages in Liebig's works bear this construction. But it is not easy to sift from the writings of that great man, in which several inconsistencies apparently occur, his real views upon the subject. Liebig himself admits that, "compared with a system of agricultural chemistry," his "book appears altogether deficient in arrangement and full of contradictions."† And, accordingly, we find such contradictory statements as the following in his celebrated work, which, notwithstanding these little discrepancies, forms the basis of the modern system of agricultural chemistry.

* Dr. Cameron has made some interesting experiments on urea, which have induced him to include it among the sources of nitrogen to plants. He sowed barley in basins of soil composed of crushed feldspar, and an artificial mineral manure in which the bases and acids corresponded as nearly as possible with the composition of the ash of the crop. Sulphate of ammonia was applied to one of these basins, and a solution of urea to two others. All the basins were covered with glass shades; the air supplied to the interior of each being freed from ammonia, by treatment with dilute sulphuric acid. From this experiment Professor Cameron concludes—1st, That the perfect development of barley can take place, under certain conditions, in soil and air free from ammonia and its constituents. 2nd, That urea, in solution, is capable of being taken, unchanged, into the organism of plants. 3rd, That urea need not be converted into carbonate of ammonia before its nitrogen becomes available to promote the process of vegetation. It has been suggested, that as urea is a very unstable compound it would soon after its application be converted into carbonate of ammonia. Liebig found that the soil has no power of absorbing and retaining urea from its solutions.

† Jour. Roy. Ag. Soc. Eng., xvii., p. 290.

(a) "The food contained in the atmosphere does not suffice to enable plants to obtain their *maximum* of size in the short period of their life. If the object of culture is to be attained, *there must be present in the soil itself an artificial atmosphere of carbonic* acid and ammonia, and this excess of nourishment, which the leaves cannot get, must be conveyed to corresponding organs in the soil."*

(a) "Ammonia accelerates and favours the growth of plants in all kinds of soil, in which exists the conditions for its assimilation."†

(b) "Is fertility not quite independent of the ammonia conveyed to the soil? If we evaporated urine, dried and burned the solid excrements, supplied to our land the salts of the urine and the ashes of the solid excrements, would not the cultivated plants grown on it—the graminæ and leguminosæ—obtain their carbon and nitrogen from the same sources whence they are obtained by the graminæ and leguminosæ of our meadows?"‡

These passages, selected from the same work, appear almost irreconcilable. In the one (a) we are told that a supply of carbonic acid and ammonia in the soil is essential, if the farmer's crops are, within the short period of their life, to attain the maximum size which they are capable of reaching—a theory to which we fully subscribe. In the other it is apparently suggested that the fertility of the soil is independent of the presence in it of ammonia, and even that the efficacy of farm-yard or any other manure is no greater than that of the ash obtained by burning it, as the carbon and nitrogen are supposed to be derivable from the air in sufficient abundance. We must not interpret Liebig's views from isolated passages, but look at them in the same bold and comprehensive spirit in which they were conceived and developed by their author. Prior to his investigations, the most intelligent agriculturists and the most renowned chemists believed that the fertility of soils and the action of manures depended exclusively on their humus or organic matter, which was regarded as endowed with a species of vitality.§ It remained for the comprehensive mind of Liebig to interpret nature more faithfully than his predecessors, and to explode these erroneous opinions. In the earlier edition of his great work,|| Liebig, while propounding the true functions of the earthy or inorganic matter of the soil, seemed to recognize the importance of the presence of organic or combustible matter, as a source of carbon and nitrogen to plants; but subsequent reflection induced him to alter his views, as may be seen from the following extracts:—

"Cultivated plants receive the same quantity of nitrogen from the atmosphere as trees, shrubs, and other wild plants; but this *is not* sufficient for the purposes of agriculture."—1st Edition, p. 85.	"Cultivated plants receive the same quantity of nitrogen from the atmosphere as trees, shrubs, and other wild plants; and this *is* quite sufficient for the purposes of agriculture."—3rd and 4th Ed., p. 54.

In a more recent publication Liebig again modified his views on the organic matter of the soil. "It was," he says, "the application of sawdust, and of the organic matter of stable manure, and of the forest soil, which I applied to a light sand, in part composed of more or less coarse quartz pebbles, which first opened my eyes to the true action of humus and decaying organic matter in the soil; and by which my previous notions on the subject were corrected and enlarged"¶—pp. 42-3. "By the progressive decay of animal manure, the animal and vegetable remains, of which it chiefly consists, are converted into carbonic acid and ammoniacal salts; hence animal manure not only supplies the plants with a certain amount of their mineral food, but also provides them in carbonic acid and ammoniacal salts; those substances which are the most in-

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* Chemistry in its Application to Agriculture, 4th Edition, p. 168.

† Ibid, p. 211. ‡ Ibid, p. 203.

§ "Organic matter," says Schworz, "is the Gordian knot which cannot be unloosened. It is the vegetable and animal extracts which determine the agricultural value of the soil." Berzelius (in his Hand-book, published in 1839), says the "Earthy part of the soil appears to exert on plants no other influence except only a mechanical one."

|| Chemistry in its Relation to Agriculture and Pathology.

¶ Principles of Agricultural Chemistry, published in 1855.

dispensable for the introduction into the vegetable organism of the mineral constituents which, by themselves, are insoluble in water, and this to a larger amount in the same time than could be effected without the co-operation of decaying organic matter"—p. 21.

12. These passages clearly prove that Liebig does not ignore the importance of organic matter in the soil. He could not be ignorant of the simple fact, that by the decomposition of animal and vegetable remains in the soil, ammonia (and, of course, ammoniacal salts) and carbonic acid were produced. He was the first to draw attention to the action of humus as a source of carbonic acid, as a solvent for phosphate of lime and earthy carbonates. Thus far we may safely accept Liebig's views. But, unfortunately, they are sometimes couched in language, sparkling though it is with eloquence, which is either so vague as not to be intelligible to the class for which they are intended, or else they bear a construction very different from that which the author intended. Sometimes passages occur which it is impossible to reconcile either with the results of practical experience or with other portions of the author's logical deductions. We have already quoted (§ 11) a passage from Liebig's work, which is at variance with the general tenor of his views, as well as with daily observation, and which led even a *practical instructor* when on his mission, diffusing agricultural knowledge among Irish farmers, to recommend them to air-dry and burn their farm-yard manure, in order to diminish the labour of carriage. Another sentence in his work—"The crops on a field diminish or increase in exact proportion to the diminution or increase of the mineral substances conveyed to it in the manure"—has also provoked much criticism. Mr. Lawes, of Rothamstead, believing that in this and other passages Liebig had propounded erroneous theories, was led to institute a series of extensive experiments, which have most materially enriched the science of agriculture, and the reports of which have called forth several piquant replies from Baron Liebig.

13. The essays on both sides are, in themselves, voluminous; and, unfortunately, the discussion has been conducted with such acrimony that, as previously observed, men's judgments seem warped by the personal interests involved. Liebig complains* that the passage just quoted, by being detached from a series of sentences, conveys a different meaning from that intended. Now, while Liebig has been foremost to elucidate the solvent action of carbonic acid, ammonia, and nitrates on the ash constituents of the soil, he would seem rather inclined to ascribe the efficacy of these substances to this solvent action, rather than to their being required to enter into the vegetable structure. Thus, in his most recent work,† he states that "we have now obtained more exact information on the part played by humus in vegetation—that by its decomposition in the soil it forms a source of carbonic acid, by which the fixed elements of food are rendered soluble, p. 54—that if the mineral constituents are sufficiently abundant, the crops will be of average productiveness without any ammonia in the soil—p. 55. He frequently suggests that only a small part of the ammonia of manures acts by its becoming food for plants, and by far the greater part by its solvent power for phosphates and silica—p. 99. Liebig does not deny that in the experiments of Mr. Lawes both properties of ammonia co-operated to produce the increased produce; but several other passages almost nullify this admission. In the lucid volume, published in 1859,‡ it is stated in very

* Principles, pp. 54-5.
† Letters on Modern Agriculture. 1859.
‡ Letters on Modern Agriculture.

intelligible words indeed—words which do not savour of ambiguity—that "the most superficial examination of a cultivated field shows that all the combustible matter of plants which are reaped from the field are derived from the air, and not from the soil"—p. 35. "The action of farm-yard manure depends, most undoubtedly, on the amount of the incombustible ash constituents of plants in it, and is determined by these"—p. 137.

14. It is true that some of the sentences previously quoted from this and other publications of Liebig are at variance with the principles inculcated in these passages; nevertheless, as they favour the assumption that the organic matter of the soil, or rather the carbonic acid, ammonia, &c., produced by its decay, do not contribute to build up the organic part of plants, and as they even favour the idea that farm-yard manure is no more efficacious than the ash obtained by burning it, it is necessary to notice them.

In 1844, Mr. Lawes found* the produce of wheat on land reduced by previous cropping to a state of agricultural exhaustion, as follows:—

	Grain. lbs.	Straw. lbs.
Unmanured	923	1120
14 tons farm-yard manure ...	1276	1476
Ashes of ditto	888	1104

15. It may be considered unnecessary at the present day to quote any experiment to prove that the value of farm-yard manure does not depend on its ash constituents alone; and Liebig may protest against any such interpretation of his views. But we maintain that while he admits the solvent action of carbonic acid, ammonia, &c., he sometimes underrates, if he does not altogether discard, the *direct* nutritive value of these compounds in the soil. Thus, in the "Letters on Modern Agriculture" it is argued, that "as our cultivated plants undoubtedly absorb through the leaves as much nitrogenized food, in the form of ammonia and nitric acid, from the air as well as dissolved in rain and dew, as uncultivated plants which receive no nitrogenized manure from the hands of man; we can, therefore, conceive that the agriculturist will seldom have to seek the reason of the failure of his crops in a deficiency of ammonia or nitrogenized food alone"—p. 78. The practice of agriculture in these countries recognises no parallel between the requirements of cultivated crops and wild plants. The latter may, and do sometimes, derive all their nitrogen from the air; but practical experience demonstrates that in many soils, and for the cereals, maximum crops are not obtainable unless there is in the soil an available supply of nitrogen. The experiments of Mr. Lawes are conclusive on this point. He raised wheat for eleven successive years on adjacent plots of land brought by previous cropping to a state of apparent exhaustion, and obtained the following results:—

	Average annual total produce. No. years.	Corn and straw
Unmanured ...	11	2864 lbs.
Mineral manure	8	3018 „
Farm-yard manure	11	5036 „
Salts of ammonia (stand. quantity)	9	4857 „
Do., with minerals	9	5331 „

This table proves that the agriculturist will often have to seek the cause of his poor crops in a deficiency of ammonia; and in such cases the efficacy of manures depends principally, though not wholly, on the presence in the soil of nitrogen in some active and available condition. And we say active and available, as contra-distinguished from the large quantity of unavailable nitrogen which appears to exist in almost all soils.

16. According to the analyses of Krocker, a German chemist, Liebig estimates that an acre of the most unfruitful soil taken to the depth of ten inches contained more ammonia than

* Jour. Roy. Agric. Soc. Eng., vol. xii., p. 8.

would supply the nitrogen to one hundred crops of wheat, or one hundred times the quantity supplied in a usual dressing of manure; while an acre of fruitful soil, of the same depth, contained from five to ten times this quantity of nitrogen.* And Mr. Way has conclusively proved, that in addition to the quantity of ammonia already locked up in the soil, it has the power of taking in a much larger quantity, from the air; and the quantity so derived is increased each time we plough, harrow, and otherwise till the ground, until the maximum is reached.

Mr. Lawes, however, has shown† (1) that the discrepancy arising from the mode of estimating the amount of nitrogen in the soil is so great that we find in several instances ten times as much recorded by one chemist as by another, for one and the same soil. (2) That the nitrogen shown to exist in soils by the methods of analyses generally adopted does not necessarily exist in a form available to plants.‡

17. That the quantity of nitrogen in soils, as determined by the general chemical processes, is not in a state fit to minister to vegetation, has been clearly evidenced by our own experiments at the Model Farm. A field on that farm, recently analyzed by Dr. Hodges, contains ·29 per cent. of nitrogen (equal to ·35 per cent. of ammonia); or per acre, taken to the depth of ten inches, upwards of a hundred times more nitrogen than is contained in 5 cwt. of Peruvian guano. Yet, on that soil it is not always judicious to dispense with nitrogen in manure. While, however, we hold that "it is obviously inadmissible to suppose that the addition of a comparatively small quantity of nitrogen to the soil, in a form proved to be readily accessible, can be of no avail, simply because the soil itself already contains a much larger absolute amount," we maintain that the presence in the soil of a large quantity of ammonia should induce the farmer to consider whether it may not be more economical to take steps (such as liming, &c.) for rendering it active than to buy a costly manure whose value depends principally on the same substance; and if, again, it contains a high per centage of organic nitrogenized matter, thorough tillage may be more judicious than the purchase of a manure, such as guano, containing a preponderating quantity of nitrogen. So that, in considering this subject, it must not be forgotten that much depends on the nature of the soil. But a careful examination of the subject has forced upon us the conviction that in practical agriculture our crops do not obtain all their nitrogen or carbon from the air; and experience has conclusively proved that heavy crops are not obtained from the ground unless it contains a due per centage of organic matter and nitrogen in some active or available state of combination.

* Soils, Chapter VI.

† Jour. Roy. Agric. Soc. Eng., vol. xvii.

‡ The quantity of nitrogen existing as ammonia, &c., in the soil is determined by burning it with a mixture of soda and lime. "By this method the nitrogen of dry organic compounds containing it is changed into ammonia; but the process does not enable us to decide whether this ammonia was entirely formed in the matter examined. In fact, a soil might furnish by analysis a very large proportion of the volatile alkali (ammonia); yet we might not be justified in affirming that it contains, I will not say this alkali already formed, but even putrescible nitrogenized substances—that is to say, those which are efficacious in vegetation."—*Boussingault.*

CHAPTER II.

THE INORGANIC ELEMENTS OF MANURES.

18. HAVING, in the foregoing chapter, considered the sources whence plants derive their organic elements, and the important functions performed by these elements in the soil, we will proceed to treat of the mineral, or ash, constituents of manures.

And here it may be remarked that manures act in several distinct ways. 1st. By directly supplying to the growing crop phosphoric acid, potash, &c. 2ndly. By producing mechanical changes in the soil, such as rendering stiff clays more porous, and light soils more coherent. 3rdly. By producing chemical changes in the soil. Lime may and does serve one or other, or all of these three purposes. If the soil does not contain the minimum quantity required for affording that substance to the growing plants, it must be supplied. Lime not only produces beneficial mechanical changes in clay soils, but by its chemical action helps to liberate the potash that exists in them in a dormant state. And, in the 4th place, manures may act by aiding the solubility of the insoluble constituents of the soil. Common salt and nitrate of soda, even in the most dilute state, dissolve a certain quantity of the insoluble phosphates, and thus the application of these salts helps to convey phosphoric acid into plants. The salts of ammonia have the same solvent action on the insoluble phosphates; and, besides, the acids of these salts may give rise to new and active compounds in the soil.

We shall have occasion to consider each of these functions of manures; but for the present shall confine ourselves principally to the first.

19. No sooner had Liebig proved that their ash constituents were essential for the growth and development of plants than he propounded the celebrated "mineral theory," according to which "every plant showed by its analyses the due proportions of the constituents essential to its growth."* Sanguine were the hopes, and high the expectations, raised by this theory, which was based on the assumption that the only thing needed to free agriculture from the errors and fallacies that oppressed it was to restore to the soil the mineral (ash) constituents abstracted from it by crops.

20. The exhaustion of land in this manner has been aptly compared to the case of a purse containing money, which will, of course, become empty, if we keep continually taking out of it, without replacing, the £ s. or d. And if we keep selling the produce of the farm—wheat, oats, and barley, milk and butter, and young stock—without making an adequate return in the shape of manure, the ground will ultimately become exhausted.

21. When first promulgated by the great German chemist, his views on the exhaustion of the soil were almost universally accepted. Unfortunately, however, they were carried too far, and writers on scientific agriculture flooded the country with pamphlets, inculcating theories, the crudest and most absurd which it is possible to

* Liebig's Familiar Letters.

conceive. Liebig, whose brilliant discoveries have illumined every department of husbandry, proposed, and actually had carried into execution, the manufacture of special mineral manures, compounded in accordance with the analyses of the ash of the plants. Viewed in a scientific point of view, nothing could be more correct than to advise farmers to replace in manures the mineral matters sold off the land—to replenish the purse. But all these special manures failed in realizing the hope that was entertained of them—namely, producing a large increase in produce of the crops to which they were immediately applied. Special manures compounded by some of Liebig's ablest disciples have failed in our own experiments; and the wheat manures prepared in these countries in strict accordance with Liebig's formulæ have proved equally abortive. And some of the experiments instituted to test Liebig's views have produced such a reaction in the minds of many intelligent agriculturists, that they regard the mineral theory as an over speculative effusion of a highly imaginative mind.

22. Mr. Lawes deduces from his scientific investigations and practical experience conclusions totally at variance with those of Liebig. The results of the numerous trials with different manures in the growth of wheat are indicated in the following table, though it embraces only one year's experience:—

	Produce per acre. Corn. lbs.	Straw. lbs.
No manure	1207	1513
14 tons farm-yard manure ...	1826	2454
2 cwt. sulphate of ammonia	1850	2244
4 cwt. Liebig's wheat manure	1400	1676
Do. with 1 cwt. sulphate and 1 cwt. muriate of ammonia	1967	2571

"The results," says Mr. Lawes, "of our experiments upon wheat and other plants of the graminaceous family have shown beyond a doubt that the character of the exhaustion which the soil suffers by their growth is essentially nitrogenous."* "If there be any truth in my experiments," says Mr. Lawes, "all hopes of obtaining annual crops of corn by mineral manures must be for ever abandoned." And again, the same able experimenter says, "The manure indicated by the resultant requirements of British agriculture has no direct connection with the composition of the mineral substances collectively found in the ashes of produce grown on, or exported from, the farm."† And again, he concludes that neither mineral manures nor carbon are indicated by his experiments "as the special or direct manures for the growth of wheat. Not so with the turnips, for the successful cultivation of which a liberal supply within the soil of carbonaceous substance and phosphate is found so important."‡

23. We see, then, that Liebig and Lawes are at issue on the mineral or ash constituents of soils and plants, no less than on the organic. Liebig would have us centre all attention on such logical reflections as these:—"It is a matter of undoubted and indubitable experience that land, of whatever quality, does not retain its capacity of yielding good crops of the same plant for an infinite series of years; but that at the end of a limited number of years the plant no longer thrives on the same soil. The cause of this loss of fertility must be looked for, and is determined by the renewal in the crops of a number of mineral substances."§ This logic, we are assured by the same authority, is alike applicable to all our cultivated plants. But the practical

* Lawes and Gilbert in Jour. Roy. Agric. Soc. Eng., vol. viii., p. 495.

† Jour. Roy. Ag. Soc. Eng., vol. xvi., p. 497.

‡ Ibid, vol. xii., p. 28.

§ Principles of Agricultural Chemistry, p. 62.

experience of nearly all British agriculturists, and more especially of those who belong to the school of high farming, and who patriotically aim at raising the produce to the maximum standard, confirms the distinction which Mr. Lawes makes as to the manurial requirements of root crops—of which the turnips may be taken as the type—and the cereals. The habits of the several families of plants, and their wants in the artificial state to which the agriculturist has brought them, are totally different. At the same time, we think the laws of vegetable growth are immutable; for, as Liebig says, no one can rationally suppose that Nature has, by way of exception, enacted special laws of nutrition for the wheat plant. And, accordingly, mineral manures compounded in accordance with the analyses of the ash of crops have failed with all crops, and in all soils deficient in organic matter.

24. But with all this we are not to discard Liebig's theory, which involves momentous interests, to some of which we purpose directing attention. The principle on which the theory is founded is sound and good; but it has been misunderstood and misapplied. That principle enables us to expose the hollow sophistry of the theory that tillage is a substitute for manure—a theory which we regard as fraught with danger to the State.

25. It is self-evident that in every plant a farmer sells there is abstracted from his soil a definite quantity of its mineral riches. The important question, then, arises, could the land continuously bear cropping without any return to it of these mineral matters? Our answer, which has the weight of universal experience, is in the negative. The question has, however, received a more qualified reply from others.

26. Thus, the Rev. Mr. Smyth, of Lois Weedon, Northamptonshire, who has, in our day, laboured with such praiseworthy zeal to revive and improve upon Tull's system of drill husbandry, that the Lois Weedon system of wheat culture has become a household phrase, has published some forty editions of a pamphlet,* the general tenor of which is, that by thorough drill culture we may, in many instances, grow wheat on the same ground without any manure. It is true Mr. Smyth does not discard manure altogether for light land, but he thinks his wheat land contains food enough, and may be safely cropped with wheat continuously without manure. "To all intents and purposes," he says, "the manure is already there, and if I add more, it is simply superfluous and extravagant."

27. We shall presently see that many wheat or clay soils contain as much of the mineral or ash constituents of plants as would, if available, supply the wants of several hundred crops of wheat without the application of any mineral manure. But, at the same time, and while we give Mr. Smyth the credit of having with ability and zeal proved the great importance of efficient tillage and drill husbandry, we regard the extremes to which his theory has been pushed as extravagant and mischievous. All wheat soils are not like the clay of Lois Weedon, which, as Mr. Lawes has proved, is capable of absorbing from the air an unusually large quantity of water and ammonia†; and that the Lois Weedon soil contains an uncommonly large store of mineral matter does not admit of doubt. Hence the danger of recommending the Lois Weedon system of

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* Word in Season. London: Ridgway.

† The per centage absorption was as follows on land under Lois Weedon wheat culture:—

	Rothamsted.	Lois Weedon.
Per centage water retained after absorption and 24 hours' exposure at 70°	5·19	5·65
Nitrogen per cent. in dry soil before absorption of ammonia	·14	·20
After ditto	·24	·33

—*Lawes in Jour. Roy. Ag. Soc. Eng.*, vol. 17.

wheat culture for universal application.

28. That system is founded on two theories, one of which is "that the atmosphere is able to afford to land duly prepared for its reception an abundant supply of every constituent of the wheat plant." We have already disproved this doctrine. The other belief on which Mr. Smyth recommends the general adoption of his system on wheat soils is, "that there is an almost unlimited supply of the mineral requisites of plants in soils; and that it is possible, from their universal prevalence, that sufficient working of the soil may enable us to dispense with any artificial manure."

29. Now, chemical analyses have taught us that many clay soils contain a very large quantity of the mineral food of plants; but it has been shown in our remarks on Soils that a considerable portion of this matter exists in such a chemical and mechanical state that it may be omitted from ordinary calculation. Mr. Smyth and his followers may say that it will become available as fast as it is necessary if the land be duly tilled, and they will even instance the success of the Lois Weedon trials in support of this view of the case. But, as already remarked, all soils are not like the clay of Lois Weedon; and it is, in our opinion, very unwise to advise, in the decided language used by Mr. Smyth, the "stout British farmer" to abandon the alternate system of husbandry for a novel plan which may appear to a few persons as applicable to the broad acres of British soil.

30. Enlightened, practical agriculturists have been often confused by the views that have emanated, from time to time, from the minds of enthusiasts. Agriculture, like many other similar sciences, afforded ample scope for the genius of speculative men. A time, however, has arrived when the great truths of agriculture must be freed from all unsafe theoretic deductions. We can no longer afford to sport with the science of manuring, like children who play with edged tools. We must study the subject with the light of true science, and for ever disconnect our minds from theories based neither on abstract science nor well attested practical experience.

31. The application of Tullian husbandry, either in its pristine form or in an amended phase of it presented to us by Mr. Smyth of Lois Weedon, cannot be advocated as a scheme worthy of any general application. Most men acquainted with the growth of our farm crops know that no matter how thoroughly we till them, there are few soils capable of bearing for even a moderate period paying crops of wheat without manure; and the longer we persevere in any such attempt the more we diminish the acreable yield.

32. A modern savant affirms the contrary in a volume whose title* alone conveys a fallacy. He states that "every soil may be said to possess its tillage zero of productive capability, below which, if the same amount of tillage is continued, no mode of cropping can reduce it. If the soil be of the ordinary kind, like that of Rothamsted, the zero may be speculatively rated at from 16 to 17 bushels of wheat per acre, with ordinary cultural appliances; while with Tullian husbandry the zero may be rated at from 24 to 25, when tillage is performed by the plough, and about 34 bushels if by the spade." We question if this assumption is true of *any* soil; and even if it were true that it is impossible to reduce the Lois Weedon wheat soil below the zero of 34 bushels (which we are by no means prepared

* Tillage a Substitute for Manure. London: Whittaker and Co.

to believe), it is a fallacy to suppose that other lands may not soon be brought to utter sterility by continued wheat culture without manure. The experience of light land farmers is sufficient to correct the judgment and modify the views of any one who entertains that notion.

33. The exhaustion of our soil is a problem worthy of the most profound reflection. We must regard it not only as it concerns our own generation, but as it affects generations yet unborn. To argue, as an author already introduced in this essay has done, that if soil is inexhaustible within the space of a hundred years or so, we need not concern ourselves with it, is a sordid, selfish, and narrow view of the subject. We write no less for the benefit of the future than for the present. And, starting from this point, we proceed to consider if the mineral food of plants is actually inexhaustible in soils.

34. Confining our attention to the principal crops, and the more important mineral constituents of soils and plants, we get the following table of the potash and phosphoric acid removed from each statute acre of ground :—

Crop.		Average produce.	Potash. lbs.	Phos. acid. lbs.
Turnips:	Bulbs	20 tons.	126	33*
	Tops	6 „	76	28
Potatoes:	Tubers	8 „	223	50
	Tops	4½ „	50½	14
Wheat:	Grain	2000 lbs.	10	15
	Straw	4000 „	24	11
Oats:	Grain	2000 „	10	10¼
	Straw	3333⅓ „	32½	4¼
Barley:	Grain	2000 „	9	17
	Straw	2500 „	28	5
Beans:	Grain	1890† „	27	28
	Straw	3360 „	107	14½
An acre, one foot deep, of the moderately retentive soil, whose analysis is given in our chapters on Soils, contains			30,200	491
„		Subsoil	108,507	778

35. Pursuing our calculations a little further, we find in this soil and subsoil as much of these two substances as the undermentioned number of annual crops of wheat contain—

	Surface soil.	Subsoil.
Potash enough for grain and straw	888	3191
„ „ grain alone	2745	9864
Phosphoric acid enough for grain and straw	166	299
„ „ for grain alone	327	518

So that the soil and subsoil (both being supposed‡ two feet deep) to which our present calculations refer contain as much phosphoric acid as would suffice for the grain of 845 crops of wheat; and the surface soil alone for 327 such crops. The surface soil of a productive field on the Albert Model Farm contains (0·06) exactly half the per centage of phosphoric acid that exists in the foregoing soil, and contains as much of that substance as the grain of 163 crops of wheat; and an additional depth of one foot of the subsoil of the Model Farm contains (0·03 per cent.) phosphoric acid, equivalent to the grain of 81 crops of wheat. Taken together, the soil and subsoil of this field possess as much phosphoric acid as the grain of 244 crops of wheat. Another fertile field on the same farm, recently analysed, contains only 0·03 per cent. of phosphoric acid. And the soil of the Munster Model Farm, which yields excellent crops, contains only ·01 per cent. in both surface soil and subsoil.§

36. It would, however, be erroneous to assert that either of these soils and subsoils would yield, without manures, as many crops of wheat as the foregoing calculations would indicate. For, in the first place, the phosphoric acid, potash, and other mineral constituents

* These figures are deduced from the mean of numerous analyses. The other mineral constituents removed by these crops are given at p. 63.

† 30 bushels, of 63 lbs. each.

‡ In the calculations in the text the average depth of soil and subsoil is taken at one foot for each, which must be looked upon as merely approximate. Many soils have a far greater workable depth; but, on the other hand, there are many soils not so deep.

§ Dr. Kirkpatrick's Report on Agricultural Schools for 1855, p. 370.

of the soil are not all in a condition available for vegetal nutrition; and, secondly, granting that they did exist in an available state, the surface of the rootlets of plants cannot come into contact with all the mineral matters in the soil.

37. A crop of wheat removes from an acre of ground 34 lbs. of potash and 26 lbs. of phosphoric acid; but, owing to the incapacity of the rootlets to come in contact with all the particles of the soil, we must not expect that wheat will come to maturity on a soil containing, per acre, and in the most available form, only 34 lbs. of potash or 26 lbs. of the acid of bone earth, even should all of the other essential mineral constituents of plants exist in abundance. We have yet to learn the quantities of its mineral constituents that denote fertility in the soil; and one of the most intricate inquiries that must be instituted, before this problem can be solved, is the determination of the ratio between the amount of nutriment in the soil in which crops grow and the food-absorbing surface of the rootlets of these crops. To illustrate the highly useful bearing of such an inquiry, and to elucidate the theory of exhaustion, we will suppose that in the case of the wheat crop on the Model Farm there exists, on an average, forty stems to the square foot—that each stem is fed by about fifty rootlets, and each rootlet may be assumed to possess the sectional area observed by Liebig, namely, one square milimètre.* The entire number of rootlets on an acre would, according to this estimate, be 87,120,000, and each would have to abstract from the soil about .003 grains of potash and .002 grains of phosphoric acid. Now, it is evident these quantities must exist in the portion of soil that immediately surrounds each rootlet, which, taking their average depth at one foot, is .0186 inches; and if .0186 inches of soil contains .002 lbs. of phosphoric acid, an acre would contain 1923 lbs. of that substance.†

38. An acre of the surface soil of the Model Farm, in which exists ·06 per cent. of phosphoric acid, contains, within a depth of one foot, 2,457 lbs. of it. If from this we deduct the minimum quantity, 1,923 lbs., here shown to be essential for the wheat crop, we have remaining as many pounds of phosphoric acid as are contained in twenty crops of wheat, and yet we cannot repeat this crop a third, and certainly not a fourth, time on that field without experiencing a falling off in the produce. This is due, in a great measure, to causes which do not belong to our present subject, and which will be noticed when we treat of the rotation of crops; but that the deficiency is partly owing to the exhaustion of the soil of mineral matters does not admit of doubt. In the present condition of the soil of the Model Farm a large portion of its phosphoric acid may be in a dormant state, and, therefore, not available for the nourishment of crops.‡ May not this objection be met by the Lois Weedon or some such system of tillage?

* A square milimètre is equal to .00155 of a square inch.

† We do not insist on the accuracy of this estimate of the minimum quantity of phosphoric acid required for the wheat crop. Many of its rootlets descend several feet in search of food. It is by no means easy to determine the amount of food absorbing surface of the rootlets of plants.

‡ "In most fields all the phosphoric acid necessary for plants is not distributed in the state in which it is readily available to the roots. One portion is simply dispersed throughout it in the form of little granules of apatite only (phosphate of lime), so that even though the soil may altogether contain more than a sufficient proportion, yet in its various portions there may exist in some too much, in others too little, for the wants of plants. The mechanical preparation of the soil would disperse these granules, but would not cause their thorough distribution and incorporation with it. To effect this requires the co-operation of a chemical action."—*Liebig's Letters on Modern Agriculture*, p. 117.

We admit at once that the farmer who wants to enrich himself by the speedy exhaustion of his land may, by efficient tillage and the application of such stimulating manures as the salts of ammonia, find the continuous growth of wheat, oats, or barley remunerative for a few years on a few soils; but sooner or later sterility will be the inevitable result of such a course of cropping. And, again, we know that the particles of the soil on which the rootlets feed, in any one year, are partly, if not wholly, exhausted in that year; and, as a matter of course, if any of the rootlets of the subsequent crops should happen to diverge in the direction of these particles, the plants will not prove of average dimensions. It is true we may obviate this difficulty by thoroughly mixing the exhausted and unexhausted portions of the soil—by ploughing, grubbing, harrowing, &c.; but we cannot by this means avert that impending permanent injury to the soil which must unavoidably follow. Year after year the annual produce will diminish; the increment of decrease may be small, and, at first, imperceptible; but slowly and surely the process of exhaustion proceeds, and the once fertile soil becomes actually exhausted and barren. The soil of the Model Farm at present yields, when regularly manured, in the periodic recurrence of a rotation, average crops of wheat; and, no doubt, by certain appliances it may be made to yield an average crop for some years without manure; but that the supply of available phosphoric acid would soon cease to be adequate to meet the wants of the plants seems pretty evident.

39. But what shall we say of the potash, sulphuric and silicic acids, lime, magnesia, iron, and chloride of sodium, which are no less essential than phosphoric acid. "These eight substances are," as Liebig beautifully expresses it, "like eight links of a chain round a wheel. If one is weak, the chain is soon broken, and the missing link is always the most important, without which the machine cannot be put in motion by the wheel." We have already supplied the number of lbs. of two of these constituent links abstracted from the soil, and present in the following table the number of lbs. per statute acre of the remaining constituents which are removed from each acre of ground:

Crop.*		Soda.	Magnesia.	Lime.	Sulphuric acid.	Silica.	Peroxide of iron.	Chloride of sodium.
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Turnips:	Bulbs	23	12¼	36	42	12	4	27
	Tops	16	9½	70	36½	2½	2½	38
Potatoes:	Tubers	7½	21	8¼	54½	17	—	12½
	Tops	29	13	30½	12¼	7	2	22
Wheat:	Grain	1¼	4	1	·1	1	·3	·04
	Straw	1½	5½	12½	8	136	2	½
Oats:	Grain	1½	4½	2¼	¼	27½	1½	·1
	Straw	16½	6½	14	5½	82	8½	—
Barley:	Grain	1¾	4	1	½	12	¾	·2
	Straw	1	6	12	3	82	2½	10½
Beans:	Grain	8	6	4	½	1	½	½
	Straw	3	13½	40	2	14	—	8½

40. To comprehend the full application of these figures, we give a table of the quantities of the several component ash constituents of plants in the moderately retentive and friable loam already referred to.

	Per centage composition.	No. lbs. of each constituent per acre.
Phosphoric acid ...	·12 ...	4800
Potash	·74† ...	29600
Soda	·22 ...	8800
Magnesia	·63† ...	25200
Lime	·77 ...	30800
Silicic acid	85·11† ...	3404400
Oxide of iron ...	3·15 ...	126000
Chlorine	trace ...	—
Sulphuric acid ...	0·22‡ ...	8800

41. This soil naturally possesses average fertility. The quantity of lime

* Acreable produce, as in page 61.

† Of these there existed in the insoluble silicates and sand—

Potash	·25
Magnesia	·50
Soda	·09
Silicic acid	85·11

‡ No sulphuric acid has been returned in the analyses, which may have arisen through mistake. We supply the per centage in the soil of the Model Farm.

in it is small in comparison with many soils; yet it exists in sufficient abundance to supply that element to crops for thousands of years. The quantity of magnesia is also adequate, and the store of iron and silica is so abundant that we may, so far as this soil is concerned, omit them in all our considerations on the subject of exhaustion. The same soil contains nearly as much potash as the grain of three thousand cereal crops. The quantity of potash in soils varies exceedingly. A clay loam, analysed by Dr. Anderson, contained 2·8 per cent. of it, which is equivalent to 448,000 lbs. per acre, supposing the soil one foot deep. In this case the supply of potash is to all intents and purposes inexhaustible. On the other hand, many light soils contain mere traces of this alkali; and it is vain to expect them to yield remunerative crops unless it is applied in manure along with any other constituents in which the soil is deficient. In either of these extremes the intelligent farmer is not so likely to err as when he has to deal with soils of average quality, on which remunerative crops have been grown for centuries without an adequate return of potash, &c. Rest, fallowing, and, more recently, alternate husbandry and drill culture, have developed the recuperative powers of those soils; but the question is, how long can they continue to yield profitable crops without any return of potash from sources foreign to the farm? How long, for example, could the soil of the Model Farm supply potash to the wheat plant? The surface soil of two fields of that farm contain respectively of potash—No. 1, 0·36; No. 2, 0·04. No. 2 would supply potash to very few consecutive corn crops, and to a still less number of crops of the potato, the tuber of which abstracts from each acre of the soil twenty times as much potash as the grain of wheat. And, accordingly, experience has long since taught the farmer that no amount of tillage will enable him to grow potatoes for a number of years without manure.

42. We have so far overlooked the consideration that in actual practice all the ash constituents of our farm crops are not removed from the soil; but find their way back again to it in farm-yard manure, &c. In modern agriculture we alternate green and grain crops. The former and the straw of the latter are principally converted into manure; so that without any artificial manures the fertility of soils, possessing a moderate quantity of phosphoric acid, potash, &c., suffers a very slight annual diminution.

43. It is the opinion of Mr. Lawes that "under a proper system of agriculture, and where grain and meat constitute almost the exclusive exports from the farm, phosphate of lime is the only mineral which it is necessary to restore directly to the farm;"* and that, "in actual practice, the available potash and soda of the soil will, from the two causes of import of cattle food and disintegration of the soil, produced by cultivation, accumulate rather than diminish."† Now, the use of oilcake and other imported concentrated cattle feeding is scarcely known among the great mass of tenant farmers of this country. When clay lands are well tilled, the potash annually liberated may equal, and even exceed, the quantity removed by the sale of crops; and, as already shown, many clays contain potash in such abundance that it is practically inexhaustible. But we have shown, at the same time, that the supply of this substance in many highly productive soils is as limited and exhaustible as phosphoric acid; and hence the principle enunciated by Mr. Lawes, that "the only mineral which, under a proper system of agriculture, it is neces-

* Jour. Roy. Ag. Soc., vol. xvii., p. 595.
† Jour. Roy. Ag. Soc. Eng., vol. xii., p. 36.

sary to restore directly to the soil is phosphate of lime," though partially, is not generally true.

44. To estimate the phosphoric acid, potash, &c., removed yearly from each acre of ground, let us suppose that a four-course rotation is followed, namely, (1) Turnips, (2) wheat, (3) grass and clover, (5) oats. The sale of the grain would cause a loss of about 5¼ lbs. potash and 6½ lbs. phosphoric acid per acre per annum. The turnips and grass are generally used for feeding cattle; and the annual loss caused in this way depends on whether the farmer breeds, or buys and fattens store, cattle. The phosphoric acid removed by the sale of farm animals would, according to Mr. Lawes, and especially if no breeding stock were kept, be less than by the sale of grain; and the amount of alkalies sent off the farm in the former would, according to direct experiments at Rothamsted, be only about one-fourth that of the phosphoric acid.*

45. As the exhaustion of each farm varies with the system of management pursued upon it, we shall endeavour to compute the total quantity of mineral matters annually removed from the soil of this country. The statistics at our command are not altogether satisfactory, but we can eliminate approximate results. It may be assumed that the soil receives back† but a relatively small proportion of the constituents removed from it in the grain of the cereal and leguminous crops, in the tuber of the potato, and in milk. Now, the amount of phosphoric acid and potash taken out of the soil of Ireland by these articles is as follows:—

	Average area under crops. Acres.	Abstracted from the soil annually. lbs. Phosphoric acid.	lbs. Potash.
		(in grain)	(in grain)
Wheat	550,000	8,250,000	6,050,000
Oats	2,000,000	21,000,000	20,000,000
Barley & Bere	270,000	4,590,000	2,430,000
Rye	15,000	135,000	75,000
Beans & Peas	13,500	364,500	378,000
		(in tubers)	(in tubers)
Potatoes	1,200,000	56,000,000	249,760,000
Milk‡	—	6,975,000	4,545,000
Total ...		97,314,500	283,238,000

46. Ninety-seven millions of pounds of phosphoric acid, and two hundred and eighty-three millions of pounds of potash, are taken out of the soil of this country annually by the crops grown for human food, and by milk! To replace the phosphoric acid it would take more than 300,000 tons of a superphosphate containing 30 per cent. of phosphate of lime, which may be regarded as the standard percentage in first class superphosphates; and it would take more than 3,700,000 tons of genuine Peruvian guano to replace the potash.§

47. The foregoing estimate does not give with scientific precision the number of pounds of phosphoric acid and potash of which the soil of Ireland is annually deprived by milk and the chief marketable crops, as a portion of the excrements of the population and live stock partly fed on these commodities finds its way back again to the fields. But, on the other hand, it omits certain other sources of waste, such as the bones, of the animals exported, &c. We will, therefore, have recourse to another mode of arriving at the result, namely,

* Jour. Roy. Ag. Soc. Eng., vol. xii., p. 36.

† Seaweed, which is used as a manure along the sea coast, brings a certain quantity of mineral matters to the soil; and the same may be said of fish.

‡ There are about 1,500,000 milch cows in Ireland, and we assume that the average yield of each is 3,000 lbs. per annum; and that the milk has the average composition given by Haidlen.

§ Bones, according to the analyses of Berzelius, contain no potash; and, consequently, superphosphates made from bones are quite incapable of restoring potash to the soil. Genuine Peruvian guano contains about 24 per cent. of phosphate of lime, or a fifth less than first class superphosphates.

a comparison of exports and imports, &c. As the quantity of phosphoric acid, &c., in the wheat and Indian corn imported is about equal to that in the cereals and pulse exported, we will confine ourselves to the exports of live stock, emigration, deaths, and sewage.

Our exports in 1858 were about 250,000 oxen, 600,000 sheep, 300,000 swine; to which add 64,337 native born Irish who emigrated, and 133,000 who died; all containing at least 25,000,000 lbs. phosphoric acid.*

48. The total population of Ireland on 31st Dec., 1858, was 6,009,113; and assuming the excrements voided daily, at the average for all ages and sexes, to be—

Of urine	... ...	2 lbs.
Fæces	... ...	3 oz.

the total phosphoric acid voided by the population is about—

In urine .	240,000,000 lbs.
In fæces .	22,000,000 lbs.
	262,000,000 lbs.

(a) It is exceedingly difficult to determine how much of this is returned to the soil. In towns having each a population of 2000 and upwards, the excrements are for the most part lost; and as these towns have an aggregate population of about 1,000,000, or one-sixth of the whole, we will assume that there is, in these towns alone, a loss of about 44,000,000 lbs. of phosphoric acid.

(b) A great portion of the fæces of the inhabitants of small towns, villages, and rural districts may be supposed to be utilised; but a very considerable portion of their urine is wasted. Taking the waste at one-fifth, there is a loss of 40,000,000 lbs. of phosphoric acid.

49. Summarising the foregoing calculations, we find the total phosphoric acid annually removed from the soil of Ireland to be—

	lbs.
a In the exports and deaths ...	25,000,000
b In the urine and fæces of the population of large towns ...	44,000,000
c Do. in rural districts ...	45,000,000
	114,000,000

We would require about 350,000 tons of superphosphate, or more than 400,000 tons of Peruvian guano, to replace this drain upon the tillage and pasture fields of Ireland.

50. It would be exceedingly interesting, and no less instructive, to compare this estimate of the exports of the mineral constituents of the soil with the consumption of guano and superphosphates, and of oilcake and other feeding substances. Unfortunately, we are again met with an insuperable obstacle in the absence of accurate statistics. We have placed ourselves in communication with the leading men engaged in the manure trade, and from their replies we conclude that there are about 10,000 tons of superphosphates and bone manures of all kinds used in this country, and, probably, about the same quantity of Peruvian guano—quantities which are small in comparison with the exports of the minerals of the soil.†

* According to Liebig, an ox weighing about 5 cwt. (550 lbs.) contains 183 lbs. bones, of which phosphoric acid is nearly 120 lbs.; and in the hide, flesh, and other parts there are 15 lbs. of phosphates. The skeleton (bones) of an adult is said to weigh from 10 to 13 lbs. According to the ultimate analysis tabulated in the Kensington Museum, the body of a man weighing 154 lbs. contained of

	lb.	oz.	grs.
Phosphorus ..	1	12	190
Nitrogen	3	8	0
Potassium	0	0	290

† We have not been able to elicit much information as to the consumption of oil-cake, &c. Messrs. M'Garry and Sons, of Cook-street, Dublin, the principal manufacturers of feeding cake, inform us that the consumption of their linseed-cake last year was 1300 tons; rape-cake, 400. The exhaustion of the arable portion of the soil may be prevented, to a greater or less extent, by converting the rocks of the country into manure. For, as Dr. Hodges forcibly remarks, in these rocks we possess enormous accumulations of phosphoric acid, and other essential elements of wheat

51. We submit that these considerations teach an important lesson to farmers, statesmen, and the nation at large. A willing soil has for centuries been robbed of its own body; and unless we heed in due time the imminent position in which we stand, a crisis may arise more terrific than any we have yet experienced. The day of retribution may be distant; but unless the British nation takes steps to avert the evil, it may, like other peoples, become degenerate and effeminate, with the deficiency of crops consequent on the exhaustion of the land.

52. A glance at the history of exhaustion in other lands confirms this view. The rapid exhaustion of many of the United States of America tells an instructive tale. In the state of New York the average produce of Indian corn decreased in ten years $3\frac{3}{4}$ bushels per acre; and the average yield of corn, which eighty years ago was from 25 to 30 bushels, is now only 12 bushels. The tobacco, a very exhausting crop, reduced many districts of the northern states—*e.g.*, Virginia and Kentucky—from extreme fertility to hopeless sterility. And in Germany, too, vine culture, which a couple of centuries ago formed a staple branch of rural industry, died out for want of nourishment, just, to use the figurative expression of Liebig, "like the flame of a lamp for want of a supply of oil."

There are those who will regard the strain of thought in which we indulge on this subject as beautiful in theory, but opposed by the history of mankind. It will be said that the acreable produce of our cultivated crops, instead of diminishing, has largely increased; and the following average acreable produce of the soil of England may be quoted from the ingenious work on "Tillage a Substitute for Manure":—

	Wheat.	Barley.	Oats.
1. In the 13th century ...	12	24	24
2. Latter end of 16th do.	16 to 20	36	32 to 40
3. Third qr. of 18th do.	23 to 24	32	36
4. Middle of the 19th do.	$26\frac{3}{8}$	38	44

These figures may or may not be true; we care not which. They do not disprove our conclusions. Agriculture, both as an art and as a science, has made progress. New appliances have enabled the farmers of each succeeding generation to develope the capabilities of the soil; and no reflecting mind can oppose our views on exhaustion by instituting a comparison between the acreable yield of land in the days of Arthur Young, when the practice of agriculture was rude and imperfect in the extreme, and that of our time, when we are guided by the light of science and aided by improved implements and other accessories of tillage. But without an adequate return of the exports of the soil, in the shape of artificial manures and cattle feeding, no amount of science or skill will suffice to maintain the land in a progressive state of fertility, or even at its present moderate productiveness. We have for centuries subjected it to a slow system of spoliation. We have weakened the links which complete the circle of fertility; and if we blindly persevere in the same course the chain will sooner or later snap, as surely as effect follows cause. There is hidden in many soils, it is true, a prodigious amount of material which the farmer can manipulate into the substance of the connecting link; but there is no such reserved store in the great bulk of our light lands, of which the productive soil of the Munster Model Farm is a convincing illustration,

and beef, of bone and milk. To some extent these resources, composed of the accumulated mineral matters of the ancient world, have been used most successfully to give our soils new powers of production. There are various chemical means which might be adopted to render these effects more energetic; and even when applied without chemical preparation, the contents of our beds of green sand, rich in animal remains, have been advantageously employed in the growth of turnips, as a substitute for dissolved bones."—*Jour. Chem. Agr. Soc. Ulster*, Feb., 1860.

CHAPTER III.

THE MONEY VALUE OF MANURES.

53. We have now glanced at the several constituents of manure, and the theory of their action, and will next proceed to consider how their money value is ascertained. This part of the subject is a little intricate, but its careful study deserves the fullest measure of attention from the farmer who wishes to purchase good manures at the cheapest cost, and to protect himself from the fraudulent practices of dishonest dealers.

Many of the constituents of manure are so abundant in the soil, or obtainable at so cheap a rate, that they are omitted in estimating the money value of manures. No doubt, the presence of the cheaper constituents in a manure may enhance its value, and make it a more complete fertilizer; but some of them are quite unnecessary for many soils, and the others are not always required. The constituents usually valued are—(1), organic matter; (2), ammonia or nitrogen; (3), insoluble phosphate of lime; (4), soluble phosphate of lime; (5), potash; (6), alkaline salts; and (7), sulphate of lime. We will consider each of these.

54.—The (1) *organic* matter of manures has been valued by some chemists at £1, and by others at 10s. per ton. It is exceedingly difficult to fix a money value upon it, as its efficacy depends on the readiness with which it would pass into carbonic acid and ammonia. This is clearly shown in the case of coal, the organic matter of which is valueless as a manure. Generally speaking, 10s. a ton is full value for organic matter, but when it contains much nitrogen, and is not derived from such a source as coal, it would be worth £1 per ton.

55.—It is not easy to fix on a standard price of (2) nitrogen, as it may exist in manure either in the form of ammonia, a salt of ammonia, or be locked up in the structure of the substances forming the manure; and its effects on plants depend materially on whether it exists in one or other of those states; so much so, that Dr. Voelcker estimates the value of the nitrogen in ammonia at one-third more than the nitrogen in animal or vegetable substances. The advanced agriculturist, who estimates the real importance of economizing time, will always seek to obtain a manure in which the nitrogen exists in a state, say, of actual ammonia, in which it can minister to vegetable nutrition as soon as it is put into the ground, in preference to the "potential" state, as Dr. Ure, many years ago, denominated the nitrogen that may, in course of time, be converted into ammonia. That it is desirable to take the state of combination of the nitrogen into account in estimating the value of a manure may be evidenced by one or two examples:—1st. Estimating the value of a specimen of Welsh coal by the quantity of nitrogen which it contains (upwards of 2 per cent.), it would be worth more than £1 per ton, and yet no farmer would pay the cost of its carriage for manure. 2ndly. We know that the organic matter of unboiled bones is one of the cheapest sources of nitrogen at our command; yet the farmer will generally find it more profitable to purchase it at a much higher price in guano, in which it exists

in a more active and available condition. In blood and horn shavings we can purchase nitrogen at a comparatively low price; but we question very much, indeed, if it be not more profitable to buy it in guano or sulphate of ammonia. It follows from these premises that the common mode of ascertaining the amount of nitrogen in manure is not satisfactory, as no attention is paid to its state of combination.

The value of the ready-formed ammonia of manures is much more easily determined than that of the nitrogen in the potential state, as it exists in several commercial salts. The liquor of the gas works is, perhaps, the cheapest source of ammonia, but the supply is so limited, compared with the present demand for ammonia, that it may be overlooked. The cheapest salt of ammonia, and the only one used extensively in agriculture, is the sulphate, a salt formed by the union of pure sulphuric acid, water, and the gas ammonia. Every 100 lbs. of pure sulphate of ammonia consist of—

Ammonia ...	... 22·7 lbs.
Sulphuric acid ...	... 53·3 „
Water	... 24·0 „

The salt of commerce contains impurities to the extent of 10 per cent. or so; we may, therefore, assume the composition of every 100 parts of commercial sulphate of ammonia to be—

Ammonia ...	... 20·4 parts.
Sulphuric acid ...	... 48·0 „
Water	... 31·6 „

The current price of the salt of commerce is from £15 to £16. If from the price of one ton of agricultural sulphate of ammonia, say £15, we deduct the value of 1,075 lbs. of sulphuric acid contained in the ton, which would be supplied by the sulphuric acid in about one ton (20¾ cwt.) of sulphate of lime, or gypsum, for about £1 10s.,* there remain £13 10s., as the cost of the 457 lbs. of ammonia in a ton of the sulphate of commerce, which is £65 6s. 4d. per ton, or a fraction over 7d. per lb. When Peruvian guano is £13 per ton, its ammonia costs about 6d. per lb., or £56 per ton.

56.—Insoluble phosphate (3) of lime exists in several commercial substances. We find 70 per cent. of it in bone ash and animal charcoal. The manure manufacturer can purchase these substances in the English market at from £4 10s. to £5 per ton. If we take the price at which they are sold to the farmer to be £6, he pays in these substances upwards of £8 10s. per ton for phosphate of lime. We have recently procured ground bones containing 46 per cent. of phosphate of lime, and 5 per cent. of nitrogen (equal to 6 per cent. of ammonia) for £7—

If from the entire cost per ton ...	£7	0	0
We deduct the value of the ammonia at £56 per ton	3	7	2
	£3	12	10

The remainder gives the cost of the 46 parts of phosphate of lime, which is equivalent to £7 16s. per ton. In coprolites we can purchase phosphate of lime cheaper than in any of the foregoing substances. Coprolites have been recently sold for 38s. and 50s. in the unground and ground state respectively. If we assume the retail price in the latter state at £3 10s. per ton, and that they contain the average percentage (56) of phosphate of lime returned by Way, the farmer could procure phosphate of lime in coprolites at £6 per ton. The chemical substance known as phosphate of lime may, therefore, be said to cost the farmer—

a, In coprolites	... £6 0 0 per ton.
b, Bone ash ...	... 8 10 0 „

* In the scale, p. 72, we value gypsum at £1 per ton; but have in this calculation assumed 30s., as it could not be obtained in the market cheaper. The sulphuric acid in sulphate of ammonia may prove more efficacious than the same acid in gypsum.

c, Ground bones	... £7 6 0	per ton.
d, And in boiled bones he ought to have it for ...	... 7 0 0	"

It is generally believed that the phosphates of coprolites are of little value until acted upon by sulphuric acid.

57.—Of all manurial constituents, (4) biphosphate of lime is the one most difficult to bring within the scope of any commercial test, as there is no substance whose sole value depends upon it. It is readily produced by pouring sulphuric acid upon any substance containing phosphate of lime. The changes that take place are thus briefly described by Dr. Cameron—1. The carbonate of lime (which is present in bones in varying proportions, 5 per cent. being a fair average) is first of all converted into sulphate of lime. 2. The basic, or insoluble phosphate of lime, loses a portion of its lime, which is appropriated by the sulphuric acid, forming with it a sulphate of lime. It is from these two causes that so large an amount of gypsum is found in vitriolized bones. 3. The lime remaining unappropriated by the sulphuric acid forms, with the excess of phosphoric acid, a compound—the bi-phosphate of lime, readily soluble in water, and containing more phosphoric acid than the insoluble phosphate. The composition of the two substances in every 100 parts has been given by Way as follows :—

	Phosphate of lime.*	Bi-phosphate.
Phosphoric acid	48½ lbs. ...	71½ lbs.
Lime ...	... 51½ " ...	28½ "

Great confusion has been produced by the two terms, soluble phosphate and bi-phosphate. The former is applied to the insoluble phosphate after it is acted upon by the acid, whereas the bi-phosphate is the name of the new combination of the phosphoric acid and lime. The bi-phosphate was also called superphosphate, but the latter name is at the present day applied to artificial manures largely depending for their value on the bi-phosphate. Every lb. of bi-phosphate of lime has been produced from 1·56 lbs. of insoluble, or what, after the action of the acid, is denominated soluble phosphate. Hence, if we multiply the percentage of bi-phosphate in any manure by 1·56, we find the corresponding amount of soluble phosphate.

In converting the phosphate into bi-phosphate of lime, we require 45 lbs. of real acid for every 100 lbs. of phosphate, or for every ton of pure phosphate we have to add 1,008 lbs. of real acid, which are supplied by 1,236 lbs. of the best vitriol of commerce. If phosphate of lime were not associated with carbonate of lime, the cost of the raw material employed in producing a ton of bi-phosphate of lime could be stated thus :—

	£	s.	d.
A ton of phosphate of lime, in coprolites, would cost	£6	0	0
To this add the value of the necessary acid—viz., 1,236 lbs., at 1d. per lb.	5	3	0
	£11	3	0
From this sum deduct the value of the sulphate of lime produced—viz., 1,725 lbs., at 30s. per	1	3	0
	£10	0	0

And we get 1,523 lbs. of bi-phosphate of lime for £10, or about £15 per ton. But phosphate of lime does not exist in nature as a distinct compound. In coprolites, bones, &c., it is associated with carbonate of lime. Now, it would take 4,000 lbs. of the coprolites to which our calculations refer to contain a ton of phosphate of lime; and this would be united with 600 lbs. of carbonate of

* Chemists are not agreed as to the precise chemical composition of phosphate of lime, or of the changes that take place in dissolving bones. For a long time the phosphate of lime in bones was expressed by the formula 3 Cao., PO_5. More recently it has been regarded as a combination of eight chemical equivalents of lime, with three equivalents of phosphoric acid, or 8 Cao., 3 PO_5. It is highly probable that the acid and base exist in different proportions in bones and coprolites. The usual formula for the biphosphate of lime is Cao., 2 Ho., PO_5.

lime,* to neutralize which there should be added about 600 lbs. sulphuric acid,

At a cost of	£2 10 0
From which deduct the value of 1,020 lbs. sulphate of lime thereby produced, at 30s. per ton ...	0 13 8
	£1 16 4
Add cost of the bi-phosphate, as determined in preceding calculation	15 0 0
And we get ...	£16 16 4

The total cost of the raw material (at retail prices) employed in producing from coprolites a ton of bi-phosphate of lime ; and by similar calculations we could determine the cost of producing it from bones, &c. It may be safely assumed that farmers would be able to procure the raw material necessary for producing a ton of bi-phosphate of lime at a cost not exceeding £20. Could the manure manufacturer sell it at this price? We are assured by some of the most respectable and intelligent men in the trade that, owing to the enormous outlay in putting up buildings and machinery, the heavy annual outlay for advertisements, the liberal commission given to local agents, and the risk of bad debts, it is quite impossible to do so. How, then, are we to arrive at the money value of a ton of this substance? It may be done in two ways —(1) We may, in the foregoing manner, estimate the cost of the raw material employed in the manufacture at trade prices†; and add a percentage sufficient to cover all expenses and casualties. We have failed in obtaining any data for arriving at a safe conclusion on this point. (2) According to the other mode of determining the money value of bi-phosphate of lime, we proceed on the supposition that all respectable manufacturers sell this substance at a fair price in artificial manures. If from the cost of a ton of any genuine superphosphate, we deduct the value of the insoluble phosphate, organic matter, ammonia, alkaline salts, and gypsum, the remainder is the price we pay for the bi-phosphate. This mode is very objectionable, and violates the commercial law which says that the price of an article is regulated by both buyer and seller. In the case before us the price of bi-phosphate of lime is determined by the manufacturer; and the only agency that can prevent its becoming exorbitant is the competition in the manure trade. The manure is, perhaps, analyzed by the chemist, who generally estimates its value. The farmer supposes that the price has been determined by the chemist; whereas, in reality, it is fixed by the manufacturer. Our view of the current unsatisfactory mode of determining the value of bi-phosphate of lime is clearly evidenced by the fact that

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* A specimen of Cambridge coprolites recently examined for us contained 15 per cent. of carbonates. The mean of three specimens of true coprolites, examined by Mr. Herepath (*vide* Jour. Roy. Ag. Soc. Eng., vol. xii., p. 101), contained 18·33 per cent. of carbonate of lime. In several specimens of coprolites a ton of phosphates would be associated with 8 cwt. of carbonate of lime (Anderson).

† The following are the terms on which Messrs. Wickens and Palmer, of 15, Mark-lane, London, offer the principal materials used in the fabrication of artificial manures. Their circular is dated January, 1860.

Guano, Peruvian, £13 and £13 10s.	per ton.
" " damaged, £7 and £11	do.
Guano, Bolivian. £8	per ton.
" Californian, £5	do.
" Kooria Mooria, £3 15s. and £5 15s.	do.
" Sombrero, £5	do.
Superphosphate of Lime, £4 15s.	do.
Dissolved Bones, £5 15s.	do.
Dried Flesh and Blood, £8	do.
Corn Manure, £5 and £6	do.
Sulphate of Ammonia, £13 10s. and £14 10s.	do.
Nitrate of Soda, £16 and £17	do.
Salt, common, £1 5s.	do.
Nitre Salt, £1 5s.	do.
Gypsum, £1 5s.	do.
Coprolite, finely ground Cambridge. £2 15s.	do.
Do. do. Suffolk, £2 10s.	do.
Apatite, £6	do.
Animal Charcoal, £4 5s. and £4 15s.	do.
Bone Ash, £4 10s. and £5 10s.	do.
Bones (cattle), £4 15s.	do.
Bones (½-inch), 16s.	per qr.
Bone Dust, 18s.	do.
Vitriol, concentrated, 1d.—10 per cent.	per lb.
" brown, ¾d.—10 per cent.	do.
Sugar Scum, 15s.	per ton.
Rags, Woollen, 80s. to 105s.	do.
Do., Land, 45s. and 70s.	do.

different scales are adopted by different chemists, which, indeed, must continue to be the case as long as these scales are deduced from the manures of different manufacturers, whose ideas of what constitutes profit are very various. And, accordingly, we find three well known analytic chemists of the present day give the following as the commercial value of a ton of

	C.	H.	A.
Soluble phosphate of lime	£20	£25	£34
Bi-phosphate of lime ...	£31	£39	£53

On the present occasion we shall adopt the medium rates, viz., £25 for soluble and £39 for bi-phosphate of lime per ton, which are the estimates of Dr. Hodges.

58. Potash can be obtained in several commercial salts, whose prices fluctuate. In carbonate of potash, at from 30s. to 42s. per cwt., potash costs from 5d. to 6½d. per lb.; in nitrate of potash, at 28s. per cwt., it costs 6¾d.; and in sulphate and muriate of potash, at 12s. or 13s. per cwt., it costs 2¼d. per lb., which in round numbers is about £20 per ton.

59. The alkaline salts, exclusive of those of potash, and including common and other salts, may be put down at £1 per ton.

60. The present market price of gypsum is about 30s. a ton. Dr. Anderson at one time seemed disposed to place no value on it in estimating the value of manures, as it is produced in superphosphates not so much for the benefit of the farmer as for the convenience of the manufacturer. More recently he values it at 10s. a ton. We adopt a medium price, £1 per ton. Tabulating the foregoing estimates, we get the following average scale of the

	Prices, per ton, of manure constituents.		
Organic matter	£0	10	0
Ammonia, 6d. per lb. ... ...=	56	0	0
Insoluble phosphate of lime } ¾d. per lb.=	7	0	0
Soluble phosphate	£25	0	0
Bi-phosphate	39	0	0
Potash, 2¼d. per lb. ... ...=	20	0	0
Alkaline (chiefly soda) salts ...	1	0	0
Gypsum (sulphate of lime) ...	1	0	0

In applying this scale for calculating the value of a ton of any manure the simplest rule is to consider the percentage of ammonia, bi-phosphate, &c., in the manure as the number of tons of those matters contained in 100 tons of the manure (for 5 per cent. means 5 tons in every 100 tons, or 5 lbs. in every 100 lbs.); multiply the percentage of each ingredient by its price per ton, and the sum of the product divided by 100 gives the price per ton. And for simplifying the calculation, decimals under ·25 may be disregarded; those from ·25 to ·75 may be considered half a unit; and those over ·75 may be reckoned an additional unit. In order to illustrate the application of the scale, we will estimate the money value of a spurious manure recently analysed by Dr. Hodges, sold in Newtownards, under the false name of bone manure. Its analysis and value may be stated thus:—

	P. cent. composition.		Value of 100 tons.		
Water	5·42 × £0	=	£0	0	0
Organic matter	19·98 × 10s.	=	10	0	0
Ammonia	None		0	0	0
Phosphate of lime	13·08 × £7	=	91	0	0
Carbonate of lime	9·30 × £0	=	0	0	0
Alkaline salts	29·18 × £1	=	29	0	0
Containing phosphoric acid, equal to soluble phosphate of lime	1.46 × £25	=	37	10	0
Sand	23·04 × £0	=	0	0	0
Value of 100 tons	...		£167	10	0
„ 1 ton	...		£1	13	6
Selling price ...	...		7	0	0
Deficit per ton	...		£5	6	6

CHAPTER IV.

FARM-YARD MANURE.

61. MANURES have been variously classified by different authors. One divides them according to their origin, into animal, vegetable, and mineral; another divides them into organic and inorganic; while a third reduces them to natural and artificial. All these classifications involve what logicians would call cross divisions. The most correct mode of classifying manures is evidently in accordance with their composition. The class-name of any manure should, therefore, be derived from the constituent on which its commercial value and efficacy depends. In accordance with this view, the principal manures at present vended have been divided into (1) nitrogenized or ammoniacal, and (2) phosphatic. But any such classification is imperfect, as many manures, *e.g.*, Peruvian guano, contain both the nitrogenized matters and phosphates. This remark is still more applicable to the most important and most universally used fertilizer, namely, farm-yard manure, which we have now to consider. Like every other manure, the fertilizing effects of farm-yard manure depends on its composition. It may, therefore, be tested by the same standard. Until very recently we possessed no accurate analyses of this substance. Dr. Voelcker, one of the first agricultural chemists of the age, has, in a paper* of great interest, published a series of analyses,* which we shall review. In the following table we give detailed analyses of farm-yard manure in (1) a fresh and (2) a well-rotted state. Both were composed of the excrements of horses, cows, and pigs, together with the straw used in littering them. The fresh manure was only fourteen days in the dung pit, during which no rain had fallen. The rotten dung was in a heap for six months, and by fermentation was reduced to "dark brown, almost black spit dung."

	Farm-yard Manure. Fresh.	Well-rotted.
Water	66·17	... 75·42
*Soluble organic matter	2·48*	... 3·71
† " ash ...	1·54†	... 1·47
‡Insoluble organic matter	25·76‡	... 12·82
§ " ash ...	4·05§	... 6·58
	100·00	100·00
* Containing nitrogen ...	0·149	... 0·297
Equal to ammonia ...	0·181	... 0·36
‡ Containing nitrogen ...	0·494	... 0·309
Equal to ammonia ...	0·599	... 0·375
The manure contains ammonia in free state[a]	0·034	... 0·046
" in form of salts[a]	0·088	... 0·057
† The soluble ash consists of—		
Soluble silica ...	·237	... ·254
Phosphate of lime ...	·299	... ·382
Lime	·066	... ·117
Magnesia	·011	... ·047
Potash	·573	... ·446
Soda	·051	... ·023
Chloride of sodium ...	·030	... ·037
Sulphuric acid ...	·055	... ·058
Carbonic acid and loss	·218	... ·106
	1·54	1·47
§ The insoluble ash consists of—		
Soluble silica ...	·967	... 1·424
Insoluble	·561	... 1·010
Oxides of iron and alumina, with phosphates	·596	... ·947
Containing phos. acid	(·178)	... (·274)

* Jour. Roy. Agric. Soc. Eng., vol. 17.

[a] In the analyses the amount of ammonia contained in the manure, in the state of volatile ammoniacal compounds, is, for the sake of brevity, called free ammonia. The portion mentioned in the state of salts is that which, after the volatile ammonia compounds are distilled off, remains behind in the manure in a fixed state.

Equal to bone earth	(·386)	...	(.573)
Lime	1·120	...	1·667
Magnesia	·143	...	·091
Potash	·099	...	·045
Soda	·019	...	·038
Sulphuric acid ...	·061	...	·063
Carbonic acid and loss	·484	...	1·295
	4·05		6·58

62. We learn several interesting facts from these analyses. Thus, weight for weight, farm-yard manure in a well rotted state contains much more soluble or active organic matter than in the fresh state. And not only is the absolute percentage amount of organic matter greater in well decomposed manure, but it is relatively richer in nitrogen. Thus, 100 parts of dry organic soluble matter from fresh dung contain 6.14 parts of nitrogen, and 100 parts of the same kind of matter from rotten dung 8.02 parts.* Well rotted dung is also richer in soluble phosphate of lime. These facts fully account for its more immediate action.

63. If we apply the commercial scale already given (p. 72) to the well rotted sample of farm-yard manure, whose analysis is given above, we shall find its value per ton, as follows :—

Organic matter ...	16·53 × 10s. =	£8·265
Ammonia	.735* × £56 =	41·160
Soluble phosphate of lime	·38 × £25 =	9·500
Insoluble do. ...	·57 × £7 =	3·890
Potash ...	·49 × £20 =	9·800
Value of 100 tons†	=	£72·615
„ of 1 ton = 14s.		

64. Farmers knew the efficacy of farm-yard manure long ere its composition was accurately ascertained; and the calculation we have made of its commercial value only confirms the views of practical men. No artificial manure can bear comparison with well made dung, which, to use the emphatic words of Dr. Voelcker, "is perfect and universal"—universal, because it contains all the constituents which our cultivated crops require for their production; perfect, because experience as well as chemical analysis show that it contains the fertilizing constituents in states of combination favourable to the luxuriant growth of these crops. Liebig insists that farm-yard manure can be replaced and even surpassed by mineral substances, sulphate of ammonia and sal-ammoniac included, and that the organic matter in farm-yard manure can be completely restored by artificial means.‡ But science and art have not yet realized this notion. And in the present state of knowledge, and as "the number of various chemical compounds in farm-yard manure is exceedingly great, and many of them, no doubt, exist in states of combination different from those in which they are obtained on analysis, it is impossible artificially to produce a concentrated, universal, and perfect manure which might entirely supersede home-made dung."§ It is quite possible that the fertile mind of Liebig or some other scientific explorer may devise some means whereby the farmer could economically dispense with farm-yard manure. At present, however, the thing seems improbable; for, whether we regard this manure as the cheapest source of nitrogen and phosphates, or as superior to all artificial manures, by virtue of the beneficial mechanical effects it has on heavy soils, no other manure can bear comparison with it. It is, therefore, to be regretted that Baron Liebig should so misconceive

* It is interesting to note that the percentage of nitrogen is greater in the soluble than the insoluble organic matter of fresh farm-yard manure. The former contains 6.04 parts of nitrogen in every 100 parts; the latter only 1.92.—*Jour. Roy. Ag. Soc. Eng.*, vol. 17, p. 199.

† In this valuation we omit the ammonia in a free state and in the state of salts; as well as the alkaline salts.

‡ Principles of Agricultural Chemistry, p. 90-91.

§ Voelcker, Jour. Roy. Ag. Soc. Eng., vol. 17, p. 202.

the real position of British agriculture as to say that "the doctrine which inculcates, as necessary for the cultivation of the land, the production of manures by green crops, and along with this the maintenance of a stock of cattle, is erroneous." In a scientific point of view, there is no connection between the production of corn and flesh; but in the present state of British agriculture the one is partially dependant on the other. They do not, as Liebig supposes, "interfere with each other." On the contrary, the production of green crops, and the feeding of cattle with them, is the most correct, because the most certain and profitable, way of maintaining and increasing the productiveness of the soil. The farmer who skilfully grows, and judiciously feeds with green crops, and utilizes all the manure produced, can assure Baron Liebig that the "production of flesh" is not, as he believes, "carried on at the expense of grain." We know many farms on which, without any extension of the area under grain, the total quantity of it produced has been increased 50 per cent. since the adoption of the very system which is condemned by the greatest living chemist. He would confine the production of meat, milk, and cheese entirely to the grazier, who ought to meddle as little as possible with the growing of grain; and the production of the latter would be restricted to a class of white crop farmers, who, on the same principle, should meddle as little as possible with the feeding of cattle.* The adoption of this doctrine would end in disappointment and national loss. Continuous white crop culture is impracticable, and even if practicable, in some cases its general adoption would be impolitic. And again, an exclusive system of grazing may be most profitable in some few spots, but the extension of that system would diminish national prosperity. The wealth of Ireland is chiefly derived from her agricultural produce—meat and corn; and the maximum of both is obtained by the adoption of a mixed system of husbandry. It is, therefore, our interest to make the production of corn dependant on green crops, cattle feeding, and farm-yard manure, and to judiciously supplement the latter with artificial manures.

65. The collection and manufacture of home-made dung should, therefore, engage the most careful attention of the farmer. With a view to its preservation, he should understand the changes it undergoes in keeping, &c. An examination of the table of analyses of fresh and well-rotted manure given in p. 73, enables us to understand the most important changes that take place during the putrefaction of dung. Like other organic bodies, farm-yard manure, in the presence of air and water, and with a certain degree of heat, undergoes chemical changes. Organic substances rich in nitrogen, such as the urine and excrements of animals, rapidly decompose, "producing disagreeable smelling gases;† while such bodies as straw, which contain but little nitrogen, decompose more slowly, and without disengaging any noxious smell." It is well to know that though water is essential for putrefaction—and perfectly dry organic matter remains unaltered for an indefinite period—yet an excess of water, by excluding air and preventing the elevation of temperature,

* *Vide* Letters on Modern Agriculture, p. 247.

† These arise principally from the sulphur and phosphorus of the nitrogenised compounds present in dung. A considerable portion of this sulphur and phosphorus combine with hydrogen, and form sulphuretted and phosphoretted hydrogen—two extremely noxious gases which escape from fermenting dung heaps. Another portion of the sulphur and phosphorus unites with atmospheric oxygen, and in the presence of porous substances becomes changed into sulphuric and phosphoric acids—two non-volatile compounds, which are left behind.—*Voelcker.*

retards the putrefactive process. And so air, though equally essential as the water, is, in excess, unfavourable to the same process, and "is productive of new changes." In farm-yard manure it is quite easy to prevent its unlimited access by compressing the heap; and, in point of fact, we can accelerate or retard the putrefaction of manure by varying the access of air* or the quantity of moisture. During the putrefaction of farm-yard manure both volatile gases and soluble organic compounds are formed. "Amongst the former, carbonic acid and ammonia deserve especial mention; amongst the latter, soluble humates and ulmates may be named. These ulmátes and humates are dark brown coloured† compounds of humic and ulmic acid, with the alkalies, potash, soda, and ammonia." As the ulmic and humic acids are formed simultaneously with, and have a powerful affinity for, ammonia, they fix and prevent the dissipation into the air of that fertilizing substance. But an elevated temperature destroys the union of ammonia with humic, ulmic, and similarly constituted acids. And a pungent smell escapes from the best regulated manure heap, which shows that all the ammonia is not fixed by the organic acids just described. It behoves us, then, to investigate still further the changes produced during the putrefaction of dung, and to ascertain if that process is not carried on at the expense of the constituents of the manure.

66. The experiments of Dr. Voelcker throw much light on this point. On the 3rd of Nov., 1854, he carefully weighed out several lots of the fresh farm-yard manure, whose analysis is given in p. 73. One of these lots (No. 1) was placed in a heap, against a stone wall, and left exposed to the air; another (No. 2) was made into a heap in a shed sheltered from rain; and a third (No. 3) was spread out in an enclosed space to the same thickness that manure is found under cattle in open yards. The heaps were carefully weighed and analysed on April 30th and August 23rd, 1855. As heap No. 2 was excluded from rain, there could be no appreciable loss of mineral matter; and as the loss of organic matters which passed directly into the air must have been produced irrespective of the solvent action of rain, an examination of the weights and analyses of this heap at different periods enables us to see clearly the loss caused by putrefaction alone.

Composition of entire heap No. 2, in lbs.

	Nov. 3, 1854.	April 30, 1855.	Aug. 23, 1855.
Total weight of heap ...	3258	1613	1297
Amount of water in heap ...	2156	917·6	563·2
Do. of solid matter ...	1102	695·4	733·8
* Soluble organic matter ...	80·77	74·68	53·56
† Insoluble do. ...	839·17	410.24	337·32
* Containing nitrogen ...	4·35	4·38	3·46
Equal to ammonia ...	5·88	5·33	4.20
† Containing nitrogen ...	16·08	14·88	13·08
Equal to ammonia ...	19·52	17·46	15·88
Total nitrogen in heap ...	20·93	19·26	16·54
Equal to ammonia ...	25·40	22·79	20·08
The heap contained ammonia in a free state	1·10	·88	·19
Ammonia in form of salts, easily decomposed by quick lime	2·86	1·62	1·33

* "If we place a lighted taper in a bottle or other enclosed vessel, it burns for a short time, and then it gradually ceases, because the air has been deprived of that matter (oxygen) which is capable of supporting combustion. In like manner, if we compress a manure heap so as to exclude fresh supplies of air, that portion which is within the heap will soon be exhausted, and then fermentation will cease."—*Trans. High. Soc.*, October, 1859, p. 91.

† Ulmic and humic acid in a free state are scarcely soluble in water, and for this reason colour it only slight brown.—*Voelcker.*

These bodies are formed only when there is a due supply of air and moisture. If from any circumstance there is a deficiency of moisture, carbonic acid is formed instead of humic and ulmic acids; and in this case volatile carbonate of ammonia is formed and readily passes into the atmosphere.—*Ibid.*

This table shows that with a loss of upwards of one-half its weight, the loss of nitrogen is very insignificant in comparison with the quantity assumed by other authors. "A heap of manure," says Mr. Edward Murphy, Professor of Agriculture, Queen's College, Cork, in a useful little manual,* "loses by fermentation, in the course of four months, two-thirds of its nitrogen"—a statement which must have caused unnecessary anxiety, if not alarm, to all who believed it. Every volume of vapour that escapes from a manure heap has been supposed to carry with it some elements of vital importance. And if on holding over the heap a piece of red litmus its colour changed to blue, it was regarded as an indication that the heap would soon be worthless. The litmus test proves the escape of ammonia; but as the most minute trace of it is sufficient to change the colour of the litmus, this test may give an exaggerated notion of the escape of ammonia. Dr. Voelcker's analyses show that a heap (No. 2) of manure weighing 3258 lbs. on 3rd Nov., 1854, had, on the 30th April, 1855, lost a quantity of nitrogen capable of producing 1·79 lb. of ammonia per ton. This is equivalent to a loss of 3·62 lbs. of ammonia on each ton of the manure, on 30th April, which is about the time of its application for green crops. Valuing ammonia at 6d. per lb., this gives a loss on that constituent alone of 1s. 9½d. per ton. Notwithstanding this loss, which appears to us very considerable, Dr. Voelcker says, "the dissipation of organic matter is not attended with any great loss of ammonia." Did he reflect that a loss of 1s. 9½d. on every ton of manure gives a loss of £1 15s. 10d. on 20 tons, which is a usual dressing per acre?

67. In almost every page of Dr. Voelcker's elaborate paper† on farm-yard manure he states that the quantity of nitrogen which escapes into the air during the putrefaction of farm-yard manure is so "inconsiderable" and "trifling" that it may be overlooked. We have shown, from data furnished by himself, that the loss deserves the serious consideration of the farmer. But Dr. Voelcker does not rest satisfied with the mere publication of his analyses. He recommends practices which to us appear at variance with his own investigations, and with the teachings of scientific and practical agriculturists. "It may, indeed," observes this renowned professor of agricultural chemistry, "be questioned whether it is more advisable to plough in the manure at once, or to let it lie for some time on the surface of the land, and to give the rain full opportunity to wash it into the soil. . . . I am much inclined to recommend, as a general rule, to cart the manure to the field, spread it over, and wait for a favourable opportunity to plough it in. In the case of clays, I have no hesitation to say the manure may be spread even six months before it is ploughed in, without losing any appreciable quantity of manuring matters. . . When no other choice is left but either to set up the manure in a heap in a corner of the field, or to spread it on the field, without ploughing it in directly, to adopt the latter plan."‡ If rain should fall and wash in the soluble constituents of the manure immediately after it is spread, and if fresh showers should fall immediately after the formation of each fresh quantity of ammonia produced by the putrefaction of the manure so spread, we could well understand the soundness of Professor Voelcker's views. His recommendation is based on two theories already

* Agricul. Instructor. Dublin: M'Glashan and Gill. p. 35.

† Jour. Roy. Ag. Soc. Eng., vol. 17.
‡ Ibid, p. 257.

referred to—(1) that manure contained "a mere trace" of ammonia in a free state, or as ready formed ammoniacal salts easily dissipated; (2) that during the fermentation of manure "the total amount of nitrogen scarcely suffered any diminution." We have disproved the latter theory, and the first is also objectionable. Fresh and well-rotted manure contained, per cent. and per ton, ammonia as follows:—

	Per centage. Fresh.	Per centage. Well rotted.	Per ton. Fresh. lbs.	Per ton. Well rotted. lbs.
Ammonia in a free state	·034	·046	·76	1·03
Ammonia in form of salts, easily decomposed by quick lime	·088	·057	1·97	1·27
	1·22	1·03	2·73	2·30

How much of this ammonia would be dissipated if the manure was spread on the land, as Dr. Voelcker suggests? In the absence of rain, and in warm weather, all the free ammonia would escape. Now, the percentage of free ammonia in farm-yard manure is small; but the amount in a usual application of it is worth preserving. Thus, in 20 tons of fresh farm-yard manure we have 15 lbs. of free ammonia, which, at 6d. per lb., comes to 7s. 6d. The farmer would consider 7s. 6d. per acre a crushing tax; and yet if he follows Dr. Voelcker's advice his manure may suffer by the dissipation of free ammonia alone to that extent. The loss of nitrogen by the exposure of farm-yard manure is not confined to the free ammonia or the ready formed salts of ammonia. By the putrefaction of the dung, more ammonia is formed, and some of it is dissipated, as has been clearly shown in the analyses of the entire heap No. 2 at different periods (p. 76). It seems to us extravagant folly to waste a substance for which we pay such an enormous price in Peruvian guano, and of which it has been estimated that 5 lbs. are competent to produce a bushel of wheat on many soils!

68. The facts and principles brought under review point to a rational system of making farm-yard manure. The arrangement of the farm-yard and offices should be made subservient to its collection and preservation. A proper receptacle should be formed for the solid dung, and, if possible, on the north side of the farm-yard. It should also be on level ground; for, if placed on sloping ground, there would be a great loss in the liquid, which would make its way down the slope; and if placed in a hollow, it becomes too much diluted or saturated with rain water. In either of these extremes, too, there is a large expenditure of unnecessary labour. It is not unusual to excavate the site of the manure heap a few inches, and to puddle the bottom with strong clay, or to pave it, using Roman cement to fill up the interstices, which completely prevents the descending of any liquid. The pit should be surrounded by a well made channel of paving stones, or tile pipes, &c., which should incline to a common point, where a liquid manure tank ought to be constructed. It is recommended to slope the bottom of the pit, so as to permit the liquid to escape the more freely into the tank; but this appears quite unnecessary when the bottom of the channel is a few inches under the bottom of the manure pit;* and more

* "In some of the best (cultivated) agricultural districts on the continent the manure-stead is separated into two divisions by a tank, usually about four feet deep, and of breadth proportionate to the size of the heap. The sides and bottom of this reservoir are well puddled with clay and lined with masonry; and the more effectually to convey into it all the drippings from the manure, the sides of the heap are surrounded with a paved channel. At one extremity of the tank a strong wooden pump is fixed, by which the liquid can, at pleasure, be discharged over the manure, by means of a canvas hose, or wooden spouts, or pumped into casks to be conveyed to the field. . . . . To prevent any loss of space, the tank, when placed across the manure-

especially if small channels be made across the site of the manure heap, and communicating with the channel that surrounds it. These cross channels should not be open, as the manure would fill them up. They are rendered unnecessary if a sufficient quantity of peat mould, or common earth, say to the depth of twelve inches, is placed underneath to absorb the liquid that percolates through the heap. When some provision is not made for absorbing or removing it, the liquid is apt to collect in too large quantity in the bottom of the heap, which prevents regular fermentation.

69. At the farm-yard there should be only one manure heap, to which the dung from the stables, byres, and piggeries should be transferred daily. There is a slovenly and wasteful practice too prevalent among farmers, namely, allowing the manure to remain in little heaps in front of the doors of the different houses, exposed to the air and rain, by which its fertilizing powers is soon diminished. These little heaps being of a conical or irregular shape, there is too large a surface exposed; and being without sufficient consolidation, putrefaction goes on too quickly, and the loss of ammonia is very rapid. Some idea of the loss that may result in this way can be formed from Dr. Voelcker's analyses of heap No. 3. As regards the loss of nitrogen, part of it escapes into the air, and part is carried off by rain water. By comparing the analyses of heaps 2 and 3 we can form a pretty accurate notion of the respective amounts of loss caused in these two ways. The loss from either source is considerable; but when both causes combine, as in heap No. 3, it is very much increased.

Composition of entire heap No. 3, in lbs.

	Nov. 3. 1854.	April 30, 1855.	Aug. 23, 1855.
Total weight of heap ..	1652	1429	1012
Amount of water in do. ..	1093	1143	709·3
" of dry matter ..	559	285·5	302 7
* Soluble organic matter ..	40·97	16·55	4·96
Soluble mineral matter ..	25·43	14.41	6·47
† Insoluble organic matter..	425·67	163·79	106 81
Insoluble do. do. ..	66·93	90.75	184·46
* Containing nitrogen ..	3 28	1·19	·60
Equal to ammonia ..	3 98	1·44	·73
† Containing nitrogen ..	6 21	6·51	3·54
Equal to ammonia ..	7·54	7 90	4·29
Total nitrogen in manure ..	9·49	7·70	4·14
Equal to ammonia ..	11·42	9·34	5·02
Total ammonia in free state	·55	·14	·13
" in form of salts, easily decomposed by quick lime	1·45	·62	.55

In the four months from April to August, 1,429 lbs. of manure lost 4·32 lbs. of ammonia, which is equivalent to 6·77 lbs. per ton; and this, at 6d. per lb., gives a loss of about 3s. 4½d. per ton. All the dung and litter removed from the live stock should, therefore, be brought into one receptacle. Each night's dung should be evenly spread on the heap next day, and a layer of peat mould or earth occasionally used as the heap is forming, to prevent the escape of ammonia. Applications of the following substances have been recommended for the same purpose:— 1. Acid substances—sulphuric acid and muriatic acid. 2. Sulphate of the protoxide of iron (commonly called green vitriol), gypsum or sulphate of lime, and common salt, have been recommended as fixers of ammonia. Of these, green vitriol is the best. It is not so dangerous as the sulphuric acid, which has a powerful corrosive action. It also acts as a deodorizer of sulphuretted hydrogen, which it completely absorbs, and with which it forms insoluble black coloured sulphuret of iron. When sulphate of iron is added to a decomposing manure heap, evolving volatile carbonate of ammonia, double decom-

stead, may be covered with a close wooden grating, and the dung piled upon it, by which means the evaporation of the liquid will be prevented, and any escaping gases absorbed by the manure."—*Hodges' Agric. Chemistry*, p. 130.

position takes place; the sulphuric acid combines with the ammonia, forming sulphate of ammonia, and the carbonic acid forms with the iron of the green vitriol a carbonate. Gypsum does not act as a deodorizer; nor does it fix the ammonia well, except in liquid manure, or when there is a sufficiency of moisture. "In manure heaps and stables, where the quantity of moisture is comparatively small, gypsum will lose its effects as a fixer of ammonia; and it is for this reason that we would confine its use, as a fixer of ammonia, to the liquid manure tank, where it can be applied with advantage" (Voelcker). Common salt has also been applied to dung heaps, under the false impression that it fixes the ammonia. It does not possess this power; but from its antiseptic property, or power of arresting putrefaction, it prevents the formation of ammonia, and may be applied with great advantage to manure heaps already sufficiently decomposed. It is worthy of remark, that besides fixing the ammonia, these substances would subsequently perform other manurial functions in the soil. But it appears to us that the application of some of them is too costly, and that farm-yard manure can be exceedingly well made and saved without those.

70. In the interior of large heaps the heat of the dung is often very great, and it is in this part of these that ammonia is given off largely. Fortunately, before it can escape into the air it has to pass through the external and cold part of the manure, which, by acting the part of a mechanical and chemical filter, with reference to ammonia, arrests its escape more or less effectually. Care should, however, be taken that the temperature does not rise too high. The exact degree is ascertained by thrusting a few pieces of stick into it. "When higher than 82° F., it should be moderated by an application of liquid from the tank. Fermentation should not be allowed to proceed farther than when the straw commences to lose its consistence, at which period it is admirably adapted to promote the growth of plants; and when it is not convenient to remove the manure to the fields, some sulphuric acid, or other fixer of ammonia, should be added to the liquid before pumping it on the heap." There are several advantages in sprinkling liquid manure over the heap of solid dung occasionally, in addition to keeping down the temperature. First, Being a highly azotised substance, it induces the decay of the straw; secondly, it adds materially to the value of the manure; and thirdly, it makes the heap more uniform in quality from top to bottom, by inducing the regular fermentation of the upper part in dry weather, which would not otherwise take place. There seems no such necessity for this practice in winter as in summer. The average temperature for the winter season is about 45°—a degree of heat at which there can be no active fermentation. It is only when, say in spring, the temperature rises to 65° that the destruction of the fibre of the straw, &c., commences. Hence many agricultural authorities consider it quite unnecessary to cover the manure with earth, &c., in winter; but the more prudent course in such cases is to err on the safe side. It is so well known among farmers that manure does not ferment in winter, that they say one load in summer is worth two loads in winter.

71. There is no small difference of opinion among practical men on the making of farm-yard manure. One experienced land steward tells us that his success in prize-taking at root-shows for years lay in his superior manure. "One ton of mine," he says, "is worth two of the stuff they make elsewhere." He explained to us his peculiar plan, which, from the importance of the subject, may be very briefly described,

Published every Friday Evening, in time for Post,

THE WEEKLY AGRICULTURAL REVIEW,

AND

IRISH COUNTRY GENTLEMAN'S NEWSPAPER.

EDITED BY PROFESSOR CHARLES A. CAMERON,

Assisted by eminent scientific and practical writers.

THE Proprietors of the New Journal have spared neither expense nor trouble in making it a worthy representative of the Agricultural Literature of the country. They are happy in being able to state that their project has the warm approval of many distinguished patrons of Agriculture; and the co-operation of some of the most eminent Agricultural writers, not only in Ireland, but also in the sister countries, has been secured.

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Whilst *The Weekly Agricultural Review*, as its name imports, is mainly devoted to the various branches of rural industry, yet articles bearing on questions of general social interest may be found in its pages.

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Whilst the pages of *The Weekly Agricultural Review* are open to fair and legitimate discussion and criticism, everything personal, or in which the general reader would not be likely to feel interested, is strictly excluded.

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THE demand for these Manures having steadily increased in Ireland, Mr. Lawes has opened an Office and Warehouse in Dublin for the convenience of purchasers, and Agents have been appointed in every town and district in the country, who will keep a stock constantly on hand.

Mr. Lawes has now manufactured and sold these manures for more than sixteen years, and they are in general use in every part of Great Britain. Their quality is guaranteed by the position they hold, as well as by the Analyses of the most eminent Chemists in England and Ireland.

The experience of the best farmers in England, Scotland, and Ireland shows that to use Guano alone for root crops is a most expensive practice. It will be found that if one-half the quantity of Guano be employed, and about the same weight of Superphosphate, *drilled with the seed*, as good a crop will be obtained, at, of course, a proportional less cost.

BARLEY AND MANGOLD MANURES.

Mr. Lawes has also prepared a Barley and Mangold Manure, which the success of last season induces him to recommend.

The Mineral Superphosphate is made entirely from minerals. The analysis by Professor Way gave 25·31 per cent. soluble, and 10·69 insoluble phosphates. It does not, therefore, differ much in the proportion of soluble and insoluble phosphates from the more expensive manure. It must be remembered, however, that the latter contains organic matter and ammonia, and also, that the insoluble phosphate of the Bone Manure is of considerable value, whilst that of the Mineral is worthless. The Mineral Manure is more easily prepared for the drill, because a superphosphate produced from bones is always more or lessadhesive, but the higher-priced manure is more economical to the farmer.

All further particulars, together with Analyses, list of Agents throughout the country, and instructions, written by Mr. Lawes, for the use of artificial manures to the different crops, may be had upon application, either personal or by letter, to Mr. Lawes' Agent in Dublin,

MR. W. H. SMITH,

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Prices at the Dublin Warehouse, if paid cash when ordered, otherwise 5 per cent will be added:—

Lawes' Patent Superphosphate or Bone Manure	...	£7 0s. per ton.
„ Mineral Superphosphate of Lime ...	...	6 0s. „
„ Barley Manure	...	8 15s. „
„ Mangold Manure	...	8 15s. „

Genuine Peruvian Guano, guaranteed to be of the importation of Messrs. Gibbs and Co. Nitrate of Soda, &c., &c., at Market prices.

NO CHARGE FOR BAGS.

AGRICULTURAL IMPLEMENTS FOR IRELAND.

RICHARD GARRETT & SONS,

LEISTON WORKS, SAXMUNDHAM, SUFFOLK,

Exporters of Machinery to all parts of the World,

(ESTABLISHED A.D. 1778,)

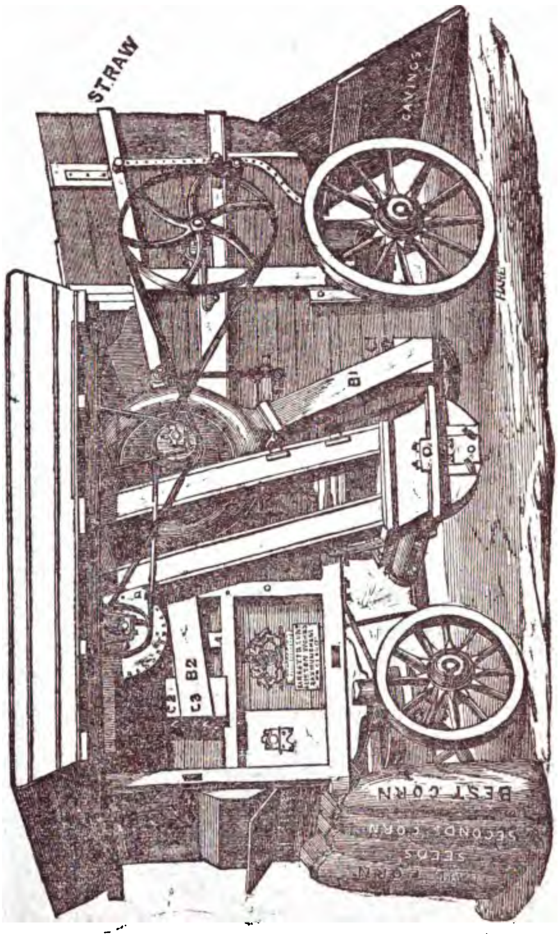
BEG most respectfully to solicit the orders of Irish Agriculturists requiring Machines of the most approved construction and adapted to their mode of cultivation. It has been their constant study to carry into effect the numerous suggestions from their friends, and of their own experience, having for their object the better adaptation of the Improved Machines of their manufacture to the requirements of the Irish Farmer, and the result

has been most successful, as the greatly increased and increasing demand goes far to prove. They are unable to give a list of the names of their customers in Ireland, as it would occupy more space than an advertisement affords; but parties requiring any description of Machines can be at once referred to persons using those of R. G. & Sons' manufacture in almost all parts of Ireland. The several Machines for which R G. & Sons are more particularly noted in Ireland retain their superiority, and give entire satisfaction wherever they are supplied, viz., the Prize Corn and Seed Drills, Patent Lever and Revolving Horse Hoes, the Dublin and Cork Prize Two-horse Power Thrashing Machines, the Improved Corn Dressing Machines, and their newly-invented Combined Finishing, Thrashing, and Dressing Machine, to which they invite particular attention, and solicit a perusal of the following.

TRIAL OF GARRETTS'

Improved Thrashing and Dressing Machine, and Report as to the efficiency of their Improved Portable Steam Engines.

RICHARD GARRETT & SONS'



PATENT PORTABLE COMBINED FINISHING, THRASHING, AND DRESSING MACHINE.

Extract from the "Irish Farmers' Gazette," August 20, 1859.

"On Monday last and succeeding days, a trial of Garretts' newly-patented combined Thrashing Machine took place at Fort Union, the farm of Mr. Christy, near Adare. Having seen and overhauled this machine at Warwick, in the yard appropriated for machinery in motion, and again at Dundalk, we were struck with the great simplicity and with some novelties introduced in its construction. Being anxious to see how the new principles introduced tallied with the practical working of the machine, we paid a visit to Mr. Christy's hospitable dwelling, to witness the practical tests to which the machine would be subjected. The machine has been described by the owners, in the Catalogues of the Warwick and Dundalk Shows, as being more compact than any of the usual machines, and containing less than half the number of bearings, spindles, pulleys, and driving belts required for the old forms of machines, and great economy in the motive powers. These points we found by inspection to be tolerably correct; but whether the performance came up to the expectation, we were anxious to see put to a practical and continuous test.

"The machine and engine, also Garrett's manufacture, arrived on Saturday at the Limerick Station from Liverpool. Two horses of Mr. Christy's were yoked to each, which brought the engine and machine from Limerick to Fort Union without being in the least distressed, and placed them in the proper position for work in a stubble field off the road. On Monday the machine was put to work on a crop of black Tartary oats grown on low land (a reclaimed bog). The oats were standing in the stook, and were damp, and some of it not well ripened. Notwithstanding, the machine thrashed and cleansed these oats in the most perfect manner, delivering them into sacks, fit for market, at the rate of 240 stone per hour. On Tuesday the machine was put to trash a very inferior crop of wheat, the straw long and damp, and the head indifferent. We had the coals weighed and time taken, when it was ascertained that 6 stone of coals worked the machine 92 minutes, delivering in that time 156 stone of perfectly dressed marketable wheat and 14 stone of second class corn. The wheat was thrashed as it stood in the stook, was damp, and not in fit condition to test the merits of the machine. On Wednesday the trial was continued, and as it was considered, from the bad condition of the crop, that the weight of corn produced in a given time was not a fair test of the capabilities of the machine, it was resolved to work it again on wheat, and to weigh the straw as delivered from the machine, this being thought, from the condition of the crop, the most correct criterion of the work performed. With a less consumption of fuel than the engine required on Tuesday, in consequence of the engine and machine being in better trim and having no stoppages, the machine delivered 125 stones of clean wheat per hour, with no less than 375 stones of straw, which is three stone of straw to one stone of corn, a very great disproportion, which serves to show the very inferior yield of corn, and we have no doubt but that, with a better crop, the machine would turn out 10 barrels per hour.

"Before the machine was set to work we examined it thoroughly, Mr. Garrett lending his aid in opening all the compartments, so as to distinctly see all its parts. The drum is of wrought iron, and the beaters, or rather rubbers, very ingeniously formed to effect extracting the grain without bruising or cutting it, and has a 7-inch bearing at both sides, which gives it a strength and steadiness not to be had with the very short bearings usual in all the machines we have yet seen, and each bearing has a lubricating box attached, which, when charged with oil in the morning, does not require a fresh supply of oil during the day, and are so covered and secured that no dust can get into the box. These bearings, as well as all others in the construction of the machine, we were informed, were case-hardened, and worked in anti-friction metal.

"The following description, with reference to the above engraving, will convey some idea as to the new points of construction. The principal improvements being in the dressing and winnowing machinery, where, instead of employing two or more blowers for producing the blasts required for thoroughly dressing the corn, the proprietors, R. Garrett and Sons, introduced a new fan (marked A in the engraving), fixed on the drum shaft, which forces a large volume of air through the trunks B 1 and B 2. The trunk B 1 conducts a blast of air under the vibrating screen, where it is brought into contact with the chaff and corn; here the first process, or rough dressing, is performed, the chaff being blown out on the opposite side of the machine; the corn is then carried up by the elevators in the usual way, and is again exposed to two separate and distinct blasts of air, supplied through the trunk B 2, by which the process of completely dressing the corn is accomplished; the strength or pressure of the several blasts is regulated at pleasure by means of the valves C 1, C 2, and C 3, fitted in the trunks B1 and B 2, and by the simple movement of these valves the necessary adjustment is effected for adapting the dressing apparatus to the various kinds and conditions of grain under operation. Lastly, the corn is passed into an improved revolving screen, and the products are delivered into sacks in four distinct samples—viz., best corn, seconds corn, tail corn, and seeds, the chaff being

delivered quite free from seeds of weeds. The separation of the four samples is based on the most scientific principles—viz., the specific gravity of each, the blast being so regulated as to balance each separate sample, by which samples of different specific gravity cannot come out at the same shoot.

"We particularly watched the working of the machine, made repeated examinations of the dressed corn as it came down, and found it, with very little exception, free of small corn, and perfectly free of the seeds of weeds, with the exception of the seeds of the galium aparina (goose grass, clivers, or robin-run-the-hedge), which no combined thrashing machine yet brought out is able to do. The assertion on the part of Mr. Garrett that the chaff was completely free of the seeds of weeds staggered us not a little, and we attentively kept a close watch on this part of the operation, and must acknowledge that so completely is the blast under the control of the attendant on the machine, that the chaff can be delivered perfectly free from the seeds of weeds, which are delivered separately. This we are enabled to assert positively, as we examined the chaff repeatedly with a magnifying-glass; and having found some small light seeds of weeds amongst it, and reporting the fact to Mr. Garrett, he so regulated the blast as to prevent its occurring, and this we were obliged to acknowledge, though rather sceptical upon it. This in itself is a vast improvement, as the chaff can be used with impunity, either as a component in food or for bedding, without any fear of the seeds of weeds being mixed with it, which hitherto has been the case, and has served to multiply weeds, and introduce them into clean land, by getting incorporated with the manure.

"The machine being the principal attraction, we have felt it right to give our observations on it at some length; but we must not let the engine pass without giving the firm of Garrett and Sons the credit they so justly merit for the admirable manner in which it is brought out, and constructed on the most improved principles, fitted with steam and gauge cocks, safety valves, governors, and all other requisites. Both engine and machine are mounted on four strong wooden carriage wheels, wrought iron axletrees, and are easily turned round and removed from place to place. Those at Mr. Christy's are of light draught, for two horses each, and the carriages are made of wrought iron throughout; in fact, as far as our examination went, which was tolerably minute, the Messrs. Garrett have spared no expense, and have done everything to render both machine and engine as durable as possible.

"The engine under notice was of six-horse power, and more than perfectly equal to the working of the machine."

Copy of Letter received by R. Garrett and Sons from William Duckett, Esq., to whom they sent one of their Improved Portable Steam Engines in June, 1859:—

"MESSRS. GARRETT AND SONS—The six-horse power Portable Steam Engine which you made for me in June last continues to work in a most superior manner. It has been in constant work for the last three months, turning a circular saw as large as thirty-six inches diameter, also thrashing, and has not been out of order once during that time. I shall certainly recommend your steam engines to any of my friends who are about to purchase one, as I consider them far superior, both in finish and workmanship, to those of other makers—I remain, yours truly,

"Duckett's Grove, Carlow, Ireland, September 13, 1859." "WILLIAM DUCKETT.

These Machines have been but recently introduced, and are adapted for preparing all kinds of grain, quite fit for market, in a thoroughly efficient manner. The points in which these new machines more particularly excel may be stated as follows:—

1st. Their compactness, being fully one-third less in size and bulk than the ordinary machines hitherto in use for the same purpose.

2nd. The great reduction in the number of wearing parts. In these improved machines more than one-half the spindles, pulleys, bearings, and driving belts required for the ordinary machines are dispensed with.

3rd. The novel arrangement by which the dressing apparatus is instantly varied while the machine is at work, to suit all kinds and conditions of grain.

4th. The very important saving in the cost of keeping the machine in working order, consequent on the great reduction in the number of wearing parts.

5th. These machines are made of 5, 6, 7, and 8 horse power, to suit small as well as large farmers.

The Price of the Five-horse Power is £85.

The following Report of a trial of R. G. & Sons' Two-horse Thrashing Machine may be found interesting:—

At the Cork Agricultural Society's Meeting, September 3rd.

(See Cork Daily Reporter, Sept. 14.)

The Prize of £5, for the best Two-horse Power Thrashing Machines.

The following is a verbatim copy of the Judges' Report:—

MR. CHAIRMAN,—We, the undersigned judges, beg to lay before you our report of the trial of Two-horse Portable Thrashing Machines, held in the Park, on September 5th, 1857 The following tabulated form shows at one glance the result of the competition:—

Name of Machine.	Number of Sheaves Thrashed.	Time of Thrashing.	Weight of clean oats Thrashed.	Weight of oats Thrashed per minute.	Revolutions per minute.	Price of Machine.
		MIN.	cwt. qr. lb.	lbs.		£
* Perrott's Two-horse patent..	120	15½	2 0 6	15	4 4½	44
† Ransome and Sims ..	120	11½	2 2 2	24½	4	43
‡ Barrett, Exall, and Andrewes	120	8	2 1 2	31½	3½ 4	42
‖ Garrett's ..	120	11	2 2 16	27	3 3½	41 15
§ M'Kenzie's ..	120	11½	2 0 27	21½	3½	35

REMARKS.

* Horses very much distressed; straw a good deal broken; first thrashing imperfectly done, although superior facilities for feeding.

† Oats well thrashed; straw not broken; horses not distressed, and most excellent machine.

‡ Oats indifferently thrashed; straw not broken; horses not distressed.

‖ Oats remarkably well thrashed; straw not broken; horses a little distressed; a superior machine.

§ Oats well thrashed; straw not broken; a capital machine for a small farmer, its cheapness being a great recommendation.

We, therefore, award the prize of £5 to Garrett's Two-horse Portable Thrashing Machine, exhibited by Mr. M'Kenzie, of Camden-quay, Cork.

Signed, S. M. HUSSY,
ROBERT BIGGS,
DAVID CUNNINGHAM.

R. G. & Sons have contracted for a low through-rate on their machines, wearing parts, &c., to Dublin *via* Liverpool, by which all exorbitant charges and the chances of delay will be avoided, and full particulars of the occasional *free* deliveries at the different Irish ports will be supplied on application.

*** Catalogues, Plans, Estimates, and Drawings, with full detailed particulars and prices of each Implement, will be supplied free, on application, by post or otherwise, at the Works, Leiston, near Saxmundham, Suffolk, and all orders promptly and carefully executed.

Leiston Works, Saxmundham, Suffolk, March, 1860.

NEW SEEDS—1860.

THE Subscribers respectfully invite the attention of Agriculturists to their stock of FARM SEEDS for the present season. All will be found of superior quality, true to name, and at moderate prices.

Their supply of GARDEN SEEDS has been selected with great care from the Stocks of Growers of the highest respectability in England and the Continent.

The assortment of Natural and Artifical Grasses, suited for permanent or alternate pasture, comprises Red and White Clover, American Cow-grass, Timothy, Cocksfoot, Foxtail, Perennial and Italian Rye-grass, Fescues, &c., which will be sold mixed or separate. Prices sent on application.

Importers of Peruvian Guano (Gibbs, Bright, and Co.). Sole Agents for Charles Norrington and Son's Superphosphate of Lime.

THOMAS M'ELROY & CO.,
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GRASS SEEDS

FOR PERMANENT PASTURE AND MEADOW.

THE Subscribers having given their most careful attention to the laying down of lands, they are now prepared to supply the Seeds of those varieties of Natural Grasses which have been found most suitable for the soil and climate of Ireland, and which, in combination with American Cow-grass, Alsike, and White Clover, yield not only the greatest bulk of herbage, but the largest amount of milking and fattening properties. The selection recommended, with cost per acre, will be furnished on application. As the seeds do not ripen properly in Ireland, what we offer are chiefly imported from Germany, and are, therefore, perfectly pure and of fine quality, and may be had in separate sorts if required.

Gentlemen ordering will please to state the nature of the land to be laid down, and the number of acres.

FREE DELIVERY.—All parcels of Seeds above £2 value (with the exception of grain and vetches) will be forwarded carriage free to any Railway Station in Ireland.

☞ Priced Catalogues of Farm, Garden, and Flower Seeds to be had, free by post, on application.

W. DRUMMOND AND SONS,

58, DAWSON-STREET, DUBLIN.

NOW OPEN,

THE

Provincial Agricultural Implement Depository,

ATHY, JANUARY, 1860.

ESTABLISHED under the Patronage of His Grace the Duke of Leinster and the Marquis of Kildare, for the purpose of facilitating the introduction of the best Agricultural Machines, by supplying them to the public direct at manufacturer's prices, with the lowest possible rates of carriage added.

To prevent the delays and expense consequent on the breakage or wear of machines of English manufacture, I beg to intimate that I will keep duplicates of the wearing parts of all the machines I sell, and competent mechanics for doing repairs.

In addition to this, I will continue to hire out, to parties who do not choose to purchase for their own use, Steam Thrashing, Corn Drilling, and Reaping Machines.

The following is a list of Standard Machines, all by the most eminent manufacturers in Britain, specimens of which will be kept for inspection in the large show-room; and, from my favourable position with regard to railway and canal communication, can be transmitted to any part of Ireland immediately on receipt of orders, relieving the purchaser from the risks of sea carriage:—

Steam Engines and Combined Thrashing Machines, portable and fixed.
Thrashing Machines for horse power.
Winnowing Machines.
One-horse Gearing for chaffing, bruising, or churning.
Corn-drilling Machines.
Turnip Drills.
Ploughs, swing and wheeled.
Harrows, iron.
Grubbers and Scarifiers.
Rollers and Clodcrushers.
Portable Steaming Apparatus.
Reaping Machines.
Grass Mowing Machines.
Hay Tedders.
Corn and Hay Rakes.
Rick Stands.
Anthony's American Churns.
Bradford's Washing, Wringing, and Mangling Machine.
Steaming Apparatus for cooking food for cattle.
Chaffing Machines.
Turnip Slicers.
Root Pulpers.
Oil-cake Crushers.
Corn Crushers.
Horse Hoes.

And every other useful implement supplied to order. Minute particulars respecting each article will be supplied on application.

I respectfully solicit the support of the nobility, landed proprietors, and farmers of Ireland, and hope, by punctual attention to their commands, to merit their approbation and patronage.

WILLIAM O'NEILL.

GENUINE AGRICULTURAL SEEDS.

(CARRIAGE FREE.)

DICKSON, HOGG, AND ROBERTSON,

SEED GROWERS AND SEED MERCHANTS,

22, MARY-STREET, DUBLIN,

RESPECTFULLY intimate that their Descriptive Priced Catalogue of Agricultural Seeds is published, and they will be happy to forward a copy to those who may not have already received it, on application.

D., H., & R. beg to remark that they have exercised the most scrupulous care in the selection of their various Agricultural Seeds, and as their immediate connection with old and well-known houses, both in England and Scotland, gives them peculiar advantages in securing the choicest samples which the English and Scotch markets produce (of which they have not been slow to avail themselves), they feel assured that their stock of Farm Seeds is such as cannot be surpassed by any house in Britain. An inspection of their samples is respectfully requested; or parties at a distance will have samples forwarded by post on application, stating particulars as to kinds, &c., &c.

Agriculturists residing in the most distant parts of Ireland will be supplied with Genuine New Seeds, at very moderate prices.

☞ All Seeds above £2 value (Grain, Potatoes, &c., excepted) delivered free at any Railway Station in Ireland.

IMPORTANT TO AGRICULTURISTS.

ARTIFICIAL MANURES, Guaranteed FREE from ADULTERATION, and subject to Chemical Analysis.

The only manure that has successfully competed against Gibbs' Peruvian Guano is

PERRY'S VITRIOLIZED BONE MANURE,

Prepared from Raw Cattle Bones and Blood, by a *peculiar chemical process*, different from that of any other Manure Manufacturer.

PERRY'S SUPERPHOSPHATE OF LIME, manufactured on the best principle, from Bones and Phosphatic Guanos, is undoubtedly by far the BEST and CHEAPEST Superphosphate in the market.

PERRY'S NITROGENIZED BLOOD MANURE, for Wheat, Oats, and Barley, requires only a trial to establish its universal use, as the BEST TOP-DRESSING for these crops. It is shipped in large quantities to England to Manure Manufacturers there, as the CHEAPEST AMMONIACAL INGREDIENT they can obtain for the preparation of GOOD MANURES.

PERRY'S CONCENTRATED URATE, for Rape, Cabbage, Mangel, or Carrots (especially on bog land) stands unequalled.

PERRY'S Potato Manure, Grass Manure, Vitriolized Peruvian Guano, Ground Bones, Vitriol, Nitrate of Soda, &c., &c.

☞ A Pamphlet, containing a full description of the above valuable Manures, the Manufacture, Composition, and Analysis—Prices, Directions for Use, &c.—together with the opinions of some of the most Scientific Agriculturists, an Almanac for 1860, and much useful Agricultural information, may be had free, from the Agents for PERRY'S Manures, in the different towns in Ireland, England, and Scotland; or will be sent post free on application to

JAMES PERRY,

Dublin Chemical Manure Works, Dolphin's-barn-lane, Dublin.

CITY OFFICE—12, EDEN-QUAY.

WHOLESALE AGENTS:

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South of Ireland—Leonard Dobbin and Co., Cork.
North of England—William Slater, Carlisle.
South of Scotland—William Murdock, Stranraer.

Retail in nearly every town in Ireland, and most of the towns in the North of England and in Scotland.

Dublin Chemical Manure Works, 1st February, 1860.

GARDEN AND FARM SEEDS.

OUR Establishment is always supplied with the finest description of AGRICULTURAL SEEDS, on the most extensive scale, grown specially for ourselves, and selected with the greatest care. Also, VEGETABLE and FLOWER SEEDS. Priced Catalogues can be had on application, in which the requisite information will be found relating to their culture.

Our Nurseries are at all times well stocked with Fruit Trees, Roses, Ornamental Shrubs, &c.

Importers of true PERUVIAN GUANO, direct from Messrs. Gibbs, Bright, & Co.

FERGUS FARRELL & SON,
119 and 120, CAPEL-STREET,
DUBLIN.

LAWES' SUPERPHOSPHATE OR BONE MANURE
REDUCED IN PRICE.

AGENTS:

W. DRUMMOND AND SONS,
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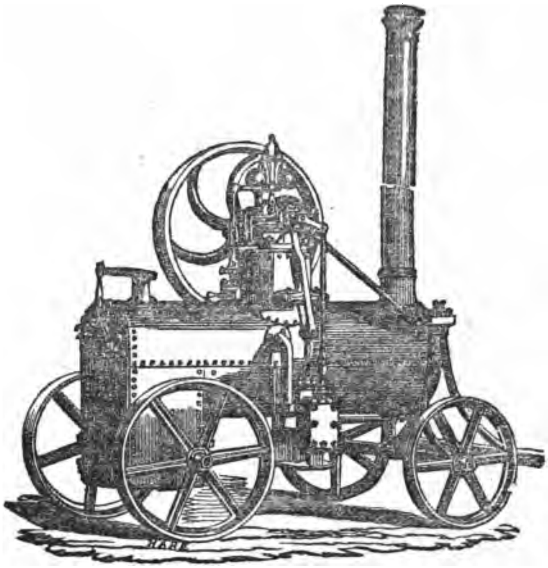

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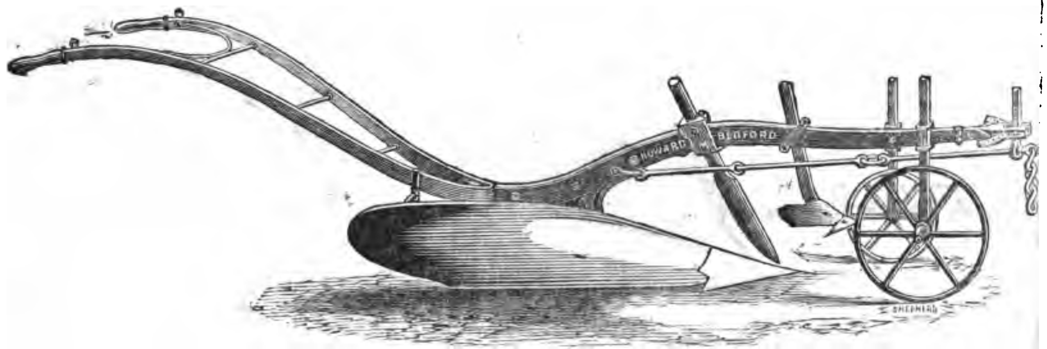

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